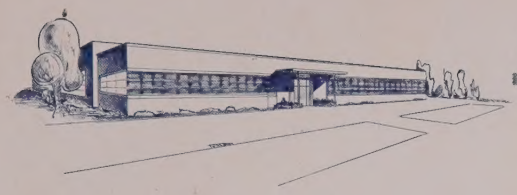

INSTRUMENT SHOP

INSTRUCTION MANUAL

MODEL 5571
FREQUENCY METER

INDUSTRIAL AND NUCLEAR INSTRUMENTS

ANALOG COMPUTERS

Berkeley division
BECKMAN INSTRUMENTS, INC.
2200 WRIGHT AVE., RICHMOND, CALIF.
TELEPHONE: LANDSCAPE 6-7730

WARNING

Do not attempt to operate this instrument

until you have read the Instruction Manual.

INSTRUMENT SHOP

INSTRUCTION MANUAL

MODEL 5571
FREQUENCY METER

Lot and above
Serial No.

BERKELEY division
Beckman Instruments, Inc.

Richmond 3, California
8 June 1956

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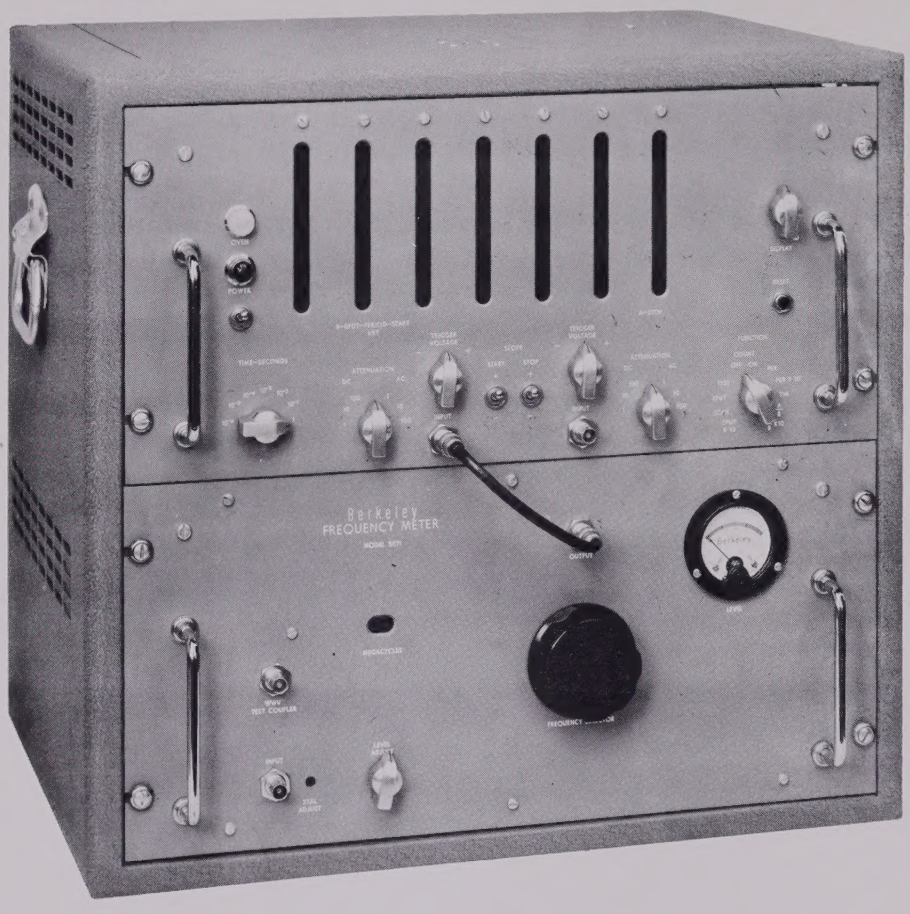

Figure 1 Model 5571 Frequency Meter

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5571

1 Introduction

DESCRIPTION

The Model 5571 Frequency Meter is composed of two relatively independent units: the Berkeley Universal Counter and Timer which occupies the upper chassis and the Heterodyne Unit on the lower chassis. The counter and timer will perform the wide variety of measurements listed under "SPECIFICATIONS". It is used alone to measure frequencies from 0 to 2.1 megacycles. The Heterodyne Unit extends the range of the counter to 42 megacycles. Frequency measurements accurate to 2 part in 10^7 ± 1 count may be made over the entire 0 to 42 MC range. Frequencies readings below 2.1 MC appear in decimal form on the seven illuminated lucite panels on the upper panel. Frequency readings above 2.1 MC are obtained simply by adding a reference frequency indicated on the lower panel to the upper panel reading.

In the Heterodyne Unit the frequency to be measured is beat against a selected reference frequency (some multiple of 1 MC) in order to produce a difference frequency within the 0 to 2.1 MC range of the counter. The basic elements of the Heterodyne Unit are a precision 1 MC crystal controlled oscillator, a harmonic generator, a harmonic selector, a mixer and an output amplifier. The counter consists of two input trigger channels, an electronic gate, a chain of Decimal Counting Units and a clock signal generator or time base. When the counter is used to measure a frequency each input signal cycle triggers a sharp voltage pulse on one of the input channels. These pulses are let through the electronic gate and counted by the DCU's during a precise time interval established by clock signals from the time base.

SPECIFICATIONS

GENERAL

Functions

1. Measures frequency or counts events-per-unit-time over a maximum automatic time interval of 10 seconds with a manual extension beyond 10 seconds for extreme accuracy.

2. Measures period of a wave or the width of a pulse. Measures ten periods when greater accuracy is desired.

3. Measures a phase angle or the time interval between two different events.

4. Measures the ratio of two frequencies or counts the number of events occuring between two similar events.

5. Counts events over a manually controlled time interval.

6. Makes self-check on accuracy of clock signals and Decimal Counting Units.

7. Performs any of the above functions with an external frequency substituted for internal clock signal.

Power requirements	117 volts ± 10%, 50 to 60 cps, 350 watts

HETERODYNE UNIT

Input frequency range	2 to 42 MC
Input impedance	100 ohms standard
Input sensitivity	100 millivolts rms
Oscillator stability	2 parts in 10^7 per week

UNIVERSAL COUNTER AND TIMER

Input Trigger Channels

Input frequency range	d-c to 2.1 MC
Input impedance	10 megohms in parallel with 35 $\mu\mu$f
Input sensitivity	100 millivolts rms, 0.3 volts peak-to-peak from d-c to 1MC increasing to 200 mv at 2MC.
Input voltage attenuation	1, 10 or 100 a-c and d-c
Overload limits	Input impedance drops below 10 megohms when input voltage rises above +10 volts d-c after attenuation.
Trigger voltage level	Adjustable from -1 to +1 volts at the attenuated signal
Trigger slope	Plus or minus

Time Base (Clock-pulse Generator)

Output frequency	10^6 to 1 cps selectable in decade steps
Output signal	2.5 volt pulse out of 330 ohms, available for external use.

Gate, Control Circuits and DCU's

Resolution	better than 0.5 μseconds
Capacity	10^7 counts
Display	Continuously variable from 0.1 to 5 seconds.
Coded output	4 line code to external connector from all decades but last

APPLICATIONS

The Model 5571 can be used to make a wide variety of frequency measurements both in the laboratory and on the production line. It is useful in designing transmitters, receivers, tuned circuits, crystals, oscillators and other equipment which must have definite frequency characteristics. On the production line the instrument is ideal for making stability checks on transmitting and receiving equipment and on crystals during heat cycling. It may also be used to calibrate less accurate frequency monitoring equipment.

The counter portion of the Model 5571 is an extremely versatile instrument. When used to measure frequencies it counts the number of voltage changes which occur during a precise time interval. However, it will also measure the time interval between two voltage changes or count the number of voltage changes which occur in the interval between two other voltage changes. Various transducers such as photocells, magnetic pickups and switches may be used to produce voltage changes representing physical events. So equipped, the instrument will measure the characteristics of such events relative to time. Some of the known applications of the instrument are:

Frequency measurements

Frequency ratio measurements

Relay and switch timing

Phase measurements

Viscosity and ballistic measurements

Elasticity measurements

Tachometry

Telemetery

Pulse height analysis

Oscilloscope time base calibration

Use as a secondary frequency standard

ACCESSORIES

The range, sensitivity and accuracy of the Model 5571 may be extended by adding auxiliary Berkeley equipment. The sensitivity can be increased to 100 microvolts with the Model 5585 Selective Amplifier. This amplifier has a band pass of ± 200 KC tunable over a range of 2 to 42 MC, a gain of 60 db and a maximum output of 0.2 volts rms from 100 ohms.

The frequency range can be extended to 515 MC by adding the Model 5580 Reference Generator and its associated Converter Units. These accessories are heterodyne units which operate on the same principle as the one in the Frequency Meter. They procure the basic 1 MC reference frequency from the Model 5571. The Model 5580 contains the initial multipliers and an amplifier. The Converter Units in the Model 5581 Series plug in to the Model 5580. They contain additional multipliers and the mixer. The Model 5581/4 covers the range of 42 to 155 MC in five bands. The model number and band coverages of the other Converter Units are as follows:

Model	Band Covered
5581/15	152 - 185 MC
5581/18	182 - 215 MC
5581/21	212 - 245 MC
5581/24	242 - 275 MC
5581/27	272 - 305 MC
5581/30	302 - 335 MC

5581/33	332 - 365 MC
5581/36	362 - 395 MC
5581/39	392 - 425 MC
5581/42	422 - 455 MC
5581/45	452 - 485 MC
5581/48	482 - 515 MC

The Model 5580 can be used independent of the converter units as a broad band amplifier. It passes frequencies from 2 to 35 MC and requires an input signal of approximately 5 mv into 100 ohms.

The Model 5575 Converter Unit is a combination of the Model 5580 and the Model 5581/4. It also covers the range of 42 to 155 MC and is an economical purchase for a buyer who is not interested in measurements within the higher ranges.

Extremely precise frequency measurements are possible when the Model 5590 WWV Receiver is used to calibrate the oscillator in the Model 5571. The receiver contains a meter for adjusting an oscillator harmonic to exactly zero beat with one of the WWV frequencies.

The versatility of the Universal Counter and Timer can be fully utilized only when it is equipped with the proper accessories. Numerous transducers such as the Model 442 Reflecting Tachometer as well as several data recording and data reduction instruments are available at Berkeley. The Model 1452 Digital Recorder, designed for use with this instrument, converts count information into a printed record. The unit prints the count accumulated by the counter during each counting period. The printed count appears sequentially in Arabic numerals on a standard adding machine tape. This recorder is ideal for making long term stability checks, recording transients, monitoring, or for making a permanent printed record in control or measuring systems.

The Model 1440 Series, Data Reduction Converters, convert digital information from the counter to a form suitable for actuating an IBM summary punch or an electric typewriter. These converters have uses similar to those of the Digital Recorder. The Model 1440S is designed for use with the IBM Summary Punch Type 523 the Model 1441S, for use with the IBM Summary Punch Type 615, and the Model 1442S, for use with an electric typewriter. On special order Berkeley will prepare a modification of the Model 1442S which will drive a teletype or a microwave link. In this way count information may be made instantaneously available at various remote locations.

The Model 1445 Digital to Analog Converter converts the count accumulated during each counting period to a representative voltage level. This voltage

is held until a new count is completed when it changes to conform with the new count. The unit may be used with a self-balancing potentiometer to provide an analog record or the changing voltage level may be used to control the operation being monitored.

With the exception of the modified Model 1442S, the instruments described above are standard accessories. Other converters, transducers and special equipment may be ordered to meet specific problems.

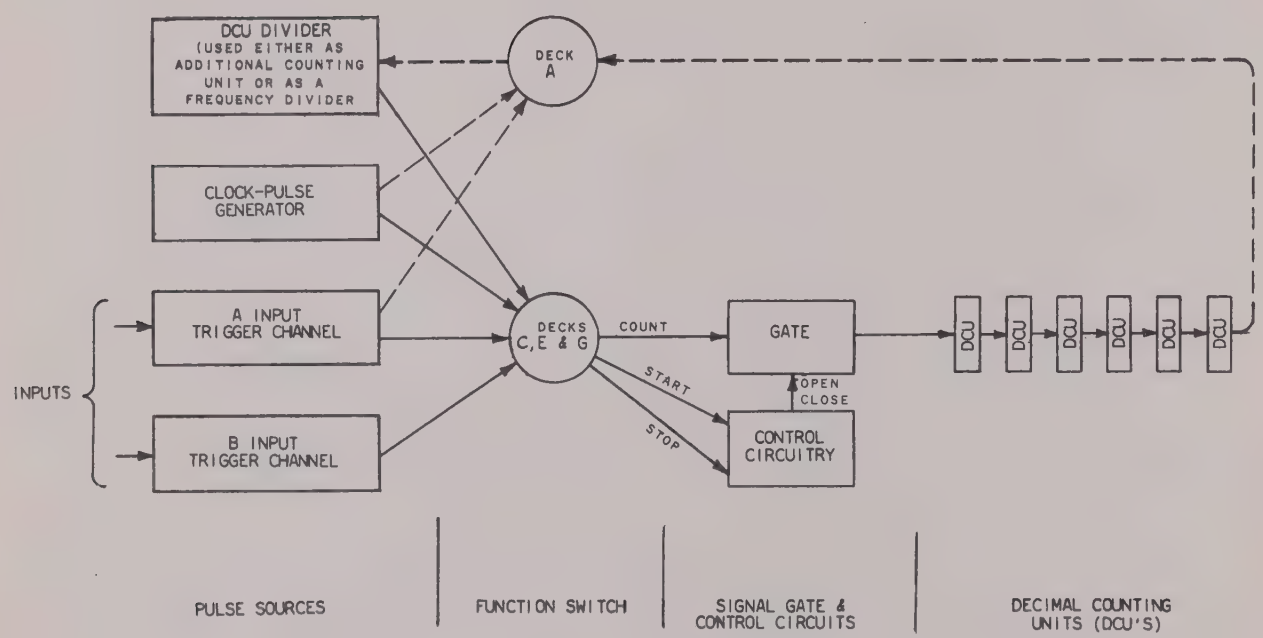


FIGURE 2. SIGNAL PATHS BETWEEN MAJOR COMPONENTS OF UNIVERSAL COUNTER AND TIMER

2 Operation

OVER-ALL DESIGN

The Model 5571 consists of a Berkeley Universal Counter and Timer supplemented by a heterodyne unit. The counter itself is a frequency meter capable of measuring frequencies from 0 to 2.1 MC. The heterodyne unit is provided merely to subtract multiples of 1 MC from frequencies above 2.1 MC so that the remainder will lie within the range of the counter. A 1 MC oscillator and a harmonic generator within the Heterodyne Unit produce all the harmonics of 1 MC from 2 to 41 MC. If, for example, a frequency of about 23.7 MC is to be measured, the FREQUENCY SELECTOR is rotated until 23 appears in the window labelled MEGACYCLES. In this position the 23 MC harmonic is mixed with the 23.7 MC input and a difference frequency of about .7 MC is fed to the counter.

The Universal Counter and Timer will make three types of measurements aside from simple counting.

1. It will count the number of events occuring during a precise time interval. This is known as events-per-unit-time E/UT Operation. Frequency measurements are made in this way. The SCAN function is a variation of this operation.

2. It will measure the time interval between two events. If the two events are represented by voltage changes on separate input channels, it is called Time-Interval-Measurement or TIM Operation. If the two events are represented on the same input channel this is known as PERIOD Operation.

3. It will count the number of events occuring between two other events. This is Ratio or A/B Operation.

If the events mentioned above are not voltage changes, appropriate transducers are used to produce voltage changes representing them at the counter INPUTS. Two input trigger channels within the counter convert the voltage changes they receive into sharp pulses. A time base in the instrument produces similar pulses separated by a precise time interval. Besides these three pulse sources the counter contains an electronic gate and a chain of decimal counting units (DCU's). The DCU's count and indicate the number of pulses which pass through the gate between a start pulse which opens it and a stop pulse which closes it.

The FUNCTION switch determines the type of measurement made by selecting the pulse source which provides each of the three signals--pulses to be counted, the start pulse and the stop pulse.

1. Under E/UT Operation one of the input channels provides pulses which are counted over the known time interval between start and stop pulses from the time base. The lighted DCU's indicate events or cycles per second with the proper placement of a decimal point.
2. Under PERIOD or TIM Operation pulses of known frequency from the clock signal generator are counted over an unknown interval between start and stop pulses from one or both of the input channels. Since the clock signal frequency is equal to the 1 MC oscillator frequency divided by a power of 10, the time measurement appears directly in decimal fractions of a second.
3. Under A/B Operation pulses from one of the input channels are counted between start and stop pulses from the other channel. If the events represented by the pulses are cycles of input signal waves, the DCU's indicate the number of cycles at one INPUT which occur during one cycle at the other INPUT or, in other words, a frequency ratio.

During all "times ten" (x 10) operations the start-stop pulse frequency is divided by 10 so that the counting period is multiplied by 10 and the reading is 10 times as large. Figures 4a through g show the selection of pulse sources for each operation.

OPERATING CONTROL & CONNECTOR FUNCTIONS

CONTROLS

	Location	Function
POWER switch	Upper Front Panel	Turns power on and off
FUNCTION Switch	Upper Front Panel	1. Interconnects major components to perform the measurement indicated by the pointer. 2. Used to manually control COUNT and SCAN operations.
TIME-SECONDS Switch	Upper Front Panel	Selects time interval for events-per-unit-time & TEST measurements and unit of time measurement for PERIOD and TIM measurements.
ATTENUATION controls	Upper Front Panel	Attenuates the signal at the adjacent INPUT jack by the voltage factor to which the pointer is set. When turned to the AC side only the a-c component of the input signal reaches the input trigger channel.
TRIGGER VOLTAGE Controls	Upper Front Panel	Selects the instantaneous voltage at which the attenuated signal triggers the adjacent input channel.
SLOPE Switches	Upper Front Panel	Selects the slope of the input voltage waveform which triggers the input channel pulse used to operate the gate and control circuitry. The input channel which each SLOPE Switch affects varies with the position of the FUNCTION switch. See "PERFORMING SPECIFIC OPERATIONS" to determine the function of the SLOPE switches at a particular position of the FUNCTION switch.
DISPLAY Time Control	Upper Front Panel	Determines how long the instrument holds a reading before resetting and beginning another count. When this control is turned to the extreme clockwise position, the instrument will hold a reading until the manual RESET button is depressed.

	Location	Function
Manual RESET button	Upper Front Panel	Removes the previous reading and readies the instrument to begin another counting period.
FREQUENCY SELECTOR Switch	Lower Front Panel	Selects the frequency indicated in the small window labelled MEGACYCLES This frequency is beat with the frequency introduced at the INPUT jack on the lower corner of the Front Panel.
LEVEL ADJUST Control	Lower Front Panel	Attenuates the signal introduced at the lower panel INPUT jack.
XTAL ADJust	Top side of upper chassis	Varies oscillator frequency slightly. DO NOT DISTRUB UNLESS A FREQUENCY STANDARD IS AVAILABLE FOR RE-CALIBRATION.
EXT-INT Switch	Upper Chassis Rear	Disables the internal oscillator when set at EXT. An external 1 MC reference frequency must then be supplied at the 1 MC OUTPUT jack.

CONNECTORS

INPUT Trigger Channel jacks B-E/UT PERIOD-START-HET and A-STOP	Upper Front Panel	Inputs to the two Input Trigger Channels. When the instrument is used to measure frequencies above 2.1 MC the B-E/UT-PERIOD-START-HET INPUT jack must be connected to the Heterodyne OUTPUT jack.
Heterodyne OUTPUT jack	Lower Front Panel	The beat frequency produced the Heterodyne Unit appears here.
WWV TEST COUPLER	Lower Front Panel	Used to couple the harmonic generator output to a standard frequency source. The entire spectrum of 1 MC harmonics appears here.
FREQUENCY Jack	Upper Chassis Rear	When the EXT-INT switch is at INTernal the 1 MC oscillator signal is available here. When the switch is at EXTernal, the external reference frequency must be connected to this jack.
1 MC INPUT Jack	Lower Chassis Rear	The 1 MC signal which is multiplied to obtain a heterodyne reference frequency must be introduced here.

COUNTER INPUT ADJUSTMENTS

NOTE: The following general discussion of input adjustments may be ignored when measuring a frequency above 2.1 MC. Specific instructions for adjusting the counter input controls for this measurement are given under "PERFORMING SPECIFIC OPERATIONS, Frequency Measurements Above 2.1 MC."

The attenuation controls labelled with DC and AC attenuation factors operate upon the signal introduced at the adjacent INPUT jack before it reaches that Input Trigger Channel. The input voltage is divided by the factor indicated by the pointer. When the pointer is on the side labelled "DC", the total input signal is attenuated and passed on to the input channel. When the pointer is on the side labelled "AC", the d-c component is removed and only the a-c component of the input signal is attenuated and passed on. Frequencies as low as 1 cps will be passed in the "AC" position.

The input channel following the attenuator produces a sharp pulse each time the attenuated input signal passes through a voltage level selected by the TRIGGER VOLTAGE (LEVEL) control. The level may be varied continuously from -1 to +1 volts. A pulse is produced when the input voltage crosses the triggering level going in a positive direction and another when it crosses going negative. Pulses triggered by positive-going voltage excursions are said to be triggered on the positive slope; pulses triggered by negative-going voltages, on the negative slope. The SLOPE switches determine whether those triggered on positive or negative slopes shall be used to operate the succeeding circuitry. THE SLOPE SWITCHES ARE NOT ALWAYS ASSOCIATED WITH THE ADJACENT INPUT CHANNEL. See "PERFORMING SPECIFIC OPERATIONS" to learn how they operate at each position of the FUNCTION Switch.

The input impedance at the jack is 10 megohms in parallel with 35 $\mu\mu$f. This impedance may be reduced to match the source or to avoid capacitive pickup by attaching a "T" connector to the jack and adding resistors or capacitors in parallel. Do not introduce an input signal stronger than 500 volts peak-to-ground. The input sensitivity is equal to 0.3 volts peak-to-peak times the factor to which the attenuation control is set.

The purpose of the Input Trigger Channel is to produce a reliable pulse output representing that part of the input signal in which the operator is interested. This is achieved only when the attenuation and TRIGGER VOLTAGE controls are properly adjusted. Before attempting to adjust the controls it is best to visualize the shape, amplitude and distance

from ground of the input signal. The effect of various control settings is then relatively easy to calculate. Refer to Figure 3 which illustrates the effect of the controls on a simple waveform. The "+" trigger voltage" and the "-" trigger voltage", separated by about 0. 3 volts, may be set anywhere from about -1 to +1 volts. The attenuated signal voltage must pass through both "-" and "+" levels to trigger pulses. To avoid overdriving the channel the attenuated signal should never rise above +10 volts.

Notice that:

1. If the attenuated signal is small the trigger voltage may be set so high or so low that no pulses are produced.
2. If the attenuated voltage variations ride on a d-c level they may not come within the trigger voltage range.
3. Any attenuated voltage variation less than 0. 3 volts peak-to-peak will not trigger pulses.
4. Modulation or variations in the d-c level of the attenuated signal are least likely to subtract pulses if the trigger voltage is set about halfway between the peaks of the signal.
5. Extraneous noise has the least effect on the time at which a pulse occurs when the channel triggers on a steep slope of the waveform.
6. Attenuating the input signal
    (a) Reduces the slope at all points.
    (b) Shifts the a-c component nearer ground if it rides on a d-c level.
    (c) Increases the minimum peak-to peak variations necessary to trigger pulses from 0. 3 volts to 3 or 30 volts.
    (d) Increases the range of possible trigger voltage settings on the input signal from 2 volts to 20 or 200 volts.

Adjustment of the attenuation and TRIGGER VOLTAGE controls should be made keeping the above characteristics in mind. When using any regular periodic input signal, consistent E/UT or PERIOD readings are a good indication that the controls are properly adjusted.

The trigger voltage may be set at a precise value by applying a d-c voltage of that value at the INPUT jack, setting the attenuation control at an appropriate factor on the DC side and rotating the TRIGGER VOLTAGE control to the point where an output pulse is produced. With no input voltage the INPUT jack lies at ground and a pulse will be produced at ground level. Output pulses from the B channel may be seen being counted when the FUNCTION switch is at E/UT. Pulses from the A channel are counted on the A/B position.

Some information about the position of the trigger voltage relative to the signal may be extracted from the instrument itself. The trigger voltage may be varied between the positive and negative peaks of an attenuated signal whose peak lie within the range -1 to +1 volts. As the trigger voltage pass beyond the signal peaks the pulse output of the channel will cease and these positions of the control may be noted.

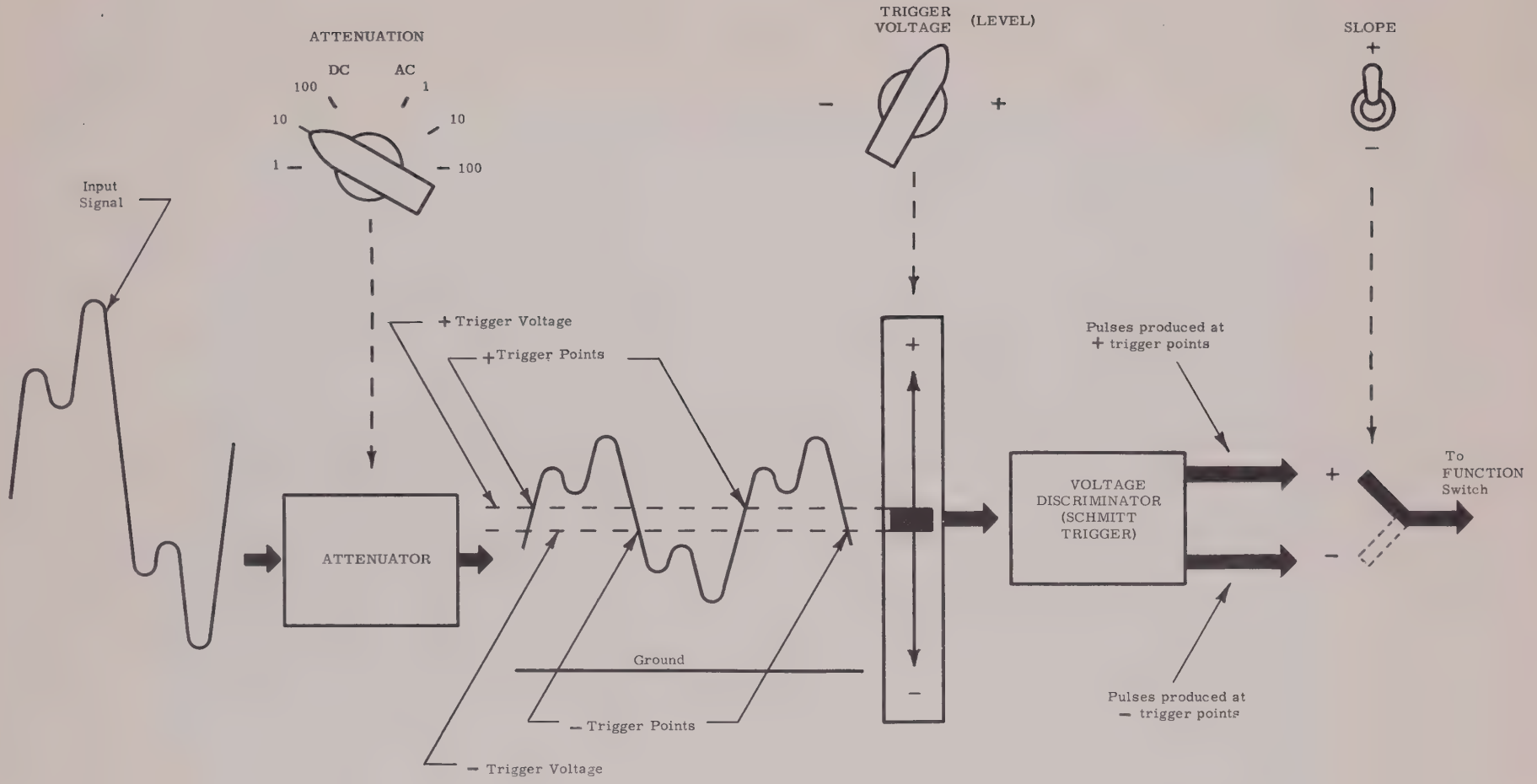


Figure 3 Effect of Input Controls

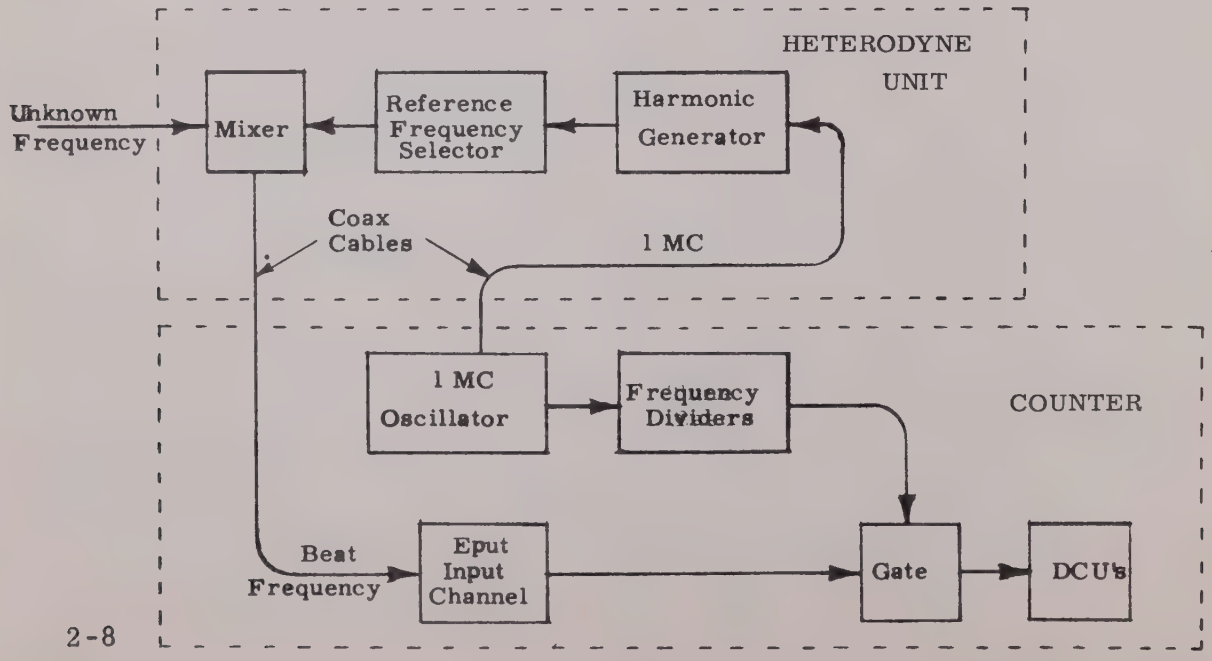
TEST Operation

To put the instrument in operation connect the power cord and place the POWER switch in the position which lights the green indicator above it. After a two minute warm-up, test the instrument for proper operation.

1. Turn DISPLAY Time to a point near the extreme counter-clockwise position to obtain a short display time and automatic operation
2. Turn FUNCTION switch to TEST.
3. Rotate TIME switch to each position starting witht the 10^{-5} seconds setting. This should give a reading of 9 or 10. As the switch is turned clockwise, other settings should be 99 or 100, 999 or 1, 000, 9, 999 or 10, 000, 99, 999 or 100, 000, and 999, 999 or 1, 000, 000 respectively.

Note that the DISPLAY Time is infinite at the extreme clockwise position of the control. In this position, the instrument must be reset manually.

Frequency Measurements Above 2 MC.



Measure frequencies below 2.1 MC using the procedure described under "E/UT or E/UT x 10 Operation". When measuring frequencies from 2.1 to 42 MC the major components are connected as diagramed. Proceed as follows:

1. Connect the source of the unknown frequency to the lower front panel INPUT jack. The input impedance is 100 ohms. The signal must be at least 100 millivolts rms, modulated less than 30%.

2. Connect a co-ax cable between the 1 MC INPUT jack on the lower chassis rear and the FREQ. jack on the upper chassis rear.

3. Connect a co-ax cable between the lower front panel OUTPUT jack and the B INPUT jack.

4. Turn the FUNCTION switch to the events-per-unit-time position or, for greater accuracy, to the events-per-unit-time x 10 position.

5. Set the B ATTENUATION control at 1 on the AC side.

6. Turn the DISPLAY time control fully counterclockwise.

7. Rotate the TIME switch to the desired time interval. For greater accuracy use a long time interval (i.e. 1 or 10^{-1} seconds).

8. Turn the LEVEL ADJUST control to the extreme clockwise position.

9. Advance the FREQUENCY SELECTOR in a clockwise direction from a reference frequency known to be below the frequency to be measured stopping at the first position at which the pointer of the LEVEL meter is deflected into the green region or beyond. The meter may show a deflection at as many as 3 switch positions. Use only the lowest position. Readings obtained elsewhere are probably incorrect.

10. Adjust the LEVEL ADJUST control so that the pointer of the LEVEL meter is at the center of the left red region.

11. Turn the TRIGGER VOLTAGE control near the B INPUT to the extreme counterclockwise position. Then rotate it slowly clockwise until the instrument begins counting. Note this position. Then turn it further clockwise until counting stops. Note this position and set the pointer midway between the place where counting started and the place where it stopped.

12. Adjust the LEVEL ADJUST control so that the pointer of the LEVEL meter is within the green region.

13. Adjust the DISPLAY time control to a position at which the count on the lighted DCU's may be read conveniently.

14. To obtain a counter reading in cycles per second divide the reading on the DCU's by the number to which the TIME switch is set. The unknown frequency is equal to the counter reading plus the reference frequency indicated by the FREQUENCY SELECTOR.

To obtain frequency measurements as accurate as possible, the internal oscillator can be tuned to exactly 1 MC. Connect the WWV TEST COUPLER on the lower front panel to the input of a WWV Receiver. Adjust the XTAL ADJ. control on the top side of the counter chassis until zero beat is obtained with the WWV signal of 5, 15, 20 or 25 MC. A special alignment tool has been supplies for this adjustment.

E/UT (Events-Per-Unit-Time) Operation

The unit counts the input to the B Channel between start and stop signals separated by a precise time interval known as the time base. This setting may be used to measure the frequency of a signal or the number of events occuring within a selected time interval. The major components are connected as diagramed in Figure 4a.

Proceed as follows:

1. Connect input to B channel. (See "COUNTER INPUT ADJUSTMENTS" above.

2. Rotate the FUNCTION switch to the events-per-unit-time position. In this position the SLOPE

switch on the B-START-E/UT-PERIOD side of panel determines the polarity of the voltage excursion which triggers count pulses. It may be at either position.

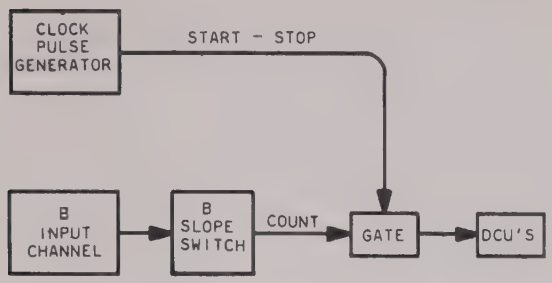


FIGURE 4a

3. Set the TIME switch at the time interval over which events are to be counted.
4. Adjust the DISPLAY time control to a position at which the count on the lighted DCU's may be read conveniently.
5. To obtain a reading in events per second, divide the reading on the lighted DCU's by the number to which the TIME switch is set.

E/UT x 10 Operation

At the E/UT x 10 position of the FUNCTION switch the unit counts every cycle of the input to the B channel between stop and start signals separated by 10 times the interval indicated by the TIME switch. This setting may be used to obtain a 10-second time interval. Counting over the 10-second period produces more accurate frequency measurements than may be made using shorter time intervals. The major components are connected as diagramed in Figure 4a except that the output of the Clock-Pulse Generator is fed through the DCU Divider before reaching the Gate. To make a measurement proceed as follows:

1. Connect input to B channel. (See "COUNTER INPUT ADJUSTMENTS" above.)
2. Rotate FUNCTION switch to the E/UT x 10 position.
3. Set the TIME switch. At this position of the FUNCTION switch the interval during which events are counted is 10 times that indicated by the TIME switch.
4. Adjust the DISPLAY TIME control for a convenient reading.
5. To obtain a reading in events per second divide the reading on the DCU's by 10 times the factor indicated by the TIME switch.

SCAN Operation

The interval during which events are counted may be extended to any multiple of the 1 or 10-second counting periods. Consider the total counting interval desired as N counting periods. Then proceed as follows:

1. Connect input to B channel. (See "COUNTER INPUT ADJUSTMENTS" above.)
2. Turn DISPLAY TIME control fully clockwise.
3. Place FUNCTION switch at E/UT or E/UT x 10.
4. Select a one or ten-second counting period. If the FUNCTION switch is at E/UT x 10 turn the TIME switch to 1 to obtain a 10-second period and to 10^{-1} to obtain a one-second period.
5. Press the RESET button. Within 1 second the instrument will begin a normal counting period.
6. Before the end of this period (one or 10 seconds as the case may be) turn the FUNCTION switch to the SCAN position and begin timing N minus 1 counting periods with a stopwatch.
7. At the end of N minus 1 periods turn the FUNCTION switch back to E/UT or E/UT X 10.
8. When the instrument stops counting, read the count. Ignore the digit (if any) appearing on the DCU farthest to the left. This DCU has not been counting continuously during the extended interval.

A/B Operation

At the A/B position of the FUNCTION switch the unit counts the signal at the A INPUT between consecutive voltage excursions through a selected level at the B INPUT. This setting may be used to measure the ratio of two frequencies or to count the number of events occurring while the B INPUT is above or below a given voltage level. The major components are connected as diagramed in Figure 4b.

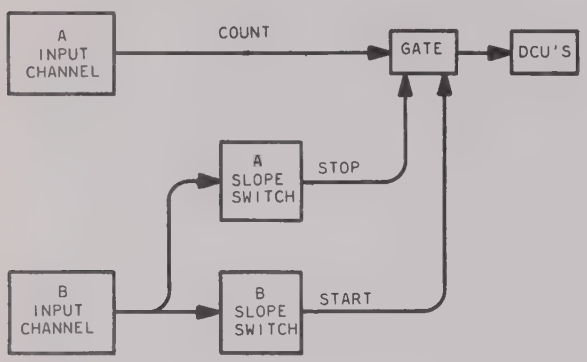


FIGURE 4b

To make a measurement proceed as follows:

1. Connect the higher frequency to the A INPUT jack and the lower frequency to the B INPUT jack. (See "COUNTER INPUT ADJUSTMENTS" above.)
2. Rotate the FUNCTION switch to A/B. In this position the SLOPE switch on the B side of the panel determines the polarity of the voltage excursion which begins count of the A input. The other SLOPE switch sets the polarity of that which ends the counting period.
3. Therefore,
   (a) When measuring the ratio of two frequencies set both SLOPE switches "+" or both to "-".
   (b) When counting the A input during the period the B input voltage remains above a certain level, set the SLOPE switch on the B side to "+" and the other to "-".
   (c) When counting the A input during the period the B input voltage remains below a certain level, set the SLOPE switch on the B side to "-" and the other to "+".
4. Adjust the DISPLAY TIME control to a position at which the count on the lighted DCU's may be read conveniently.
5. Take a reading. When measuring a frequency ratio the DCU's indicate the ratio of the A input frequency to the B input frequency.

A/B x 10 Operation

At the A/B x 10 position of the FUNCTION switch the unit counts the signal at the A INPUT between a voltage excursion through a selected level at the B INPUT and the tenth following excursion. This setting will measure a frequency ratio more accurately than the A/B operation. The major components are connected as diagramed in Figure 4c.

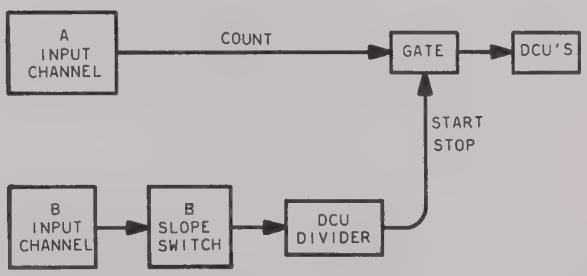


FIGURE 4c

To make a measurement proceed as follows:

1. Connect the higher frequency to the A INPUT jack and the lower frequency to the B INPUT jack. (See "COUNTER INPUT ADJUSTMENT" above).
2. Rotate the FUNCTION switch to A/B x 10. In this position the B SLOPE switch determines the polarity of the voltage excursion which begins and ends counting.
3. For greatest accuracy set this SLOPE switch on the steeper slope of the B input
4. Adjust the DISPLAY TIME control to a position at which the count on the lighted DCU's may be read conveniently.

5. Divide the reading by 10 to obtain the ratio of the A INPUT frequency to the B INPUT frequency.

TIM (Time-Interval-Meter) Operation

At TIM position of the FUNCTION switch the unit measures the time between a voltage excursion through a selected level at the B (START) INPUT and a voltage excursion through an independently chosen level at the A (STOP) INPUT. The major components are connected as diagramed in **Figure 4d.**

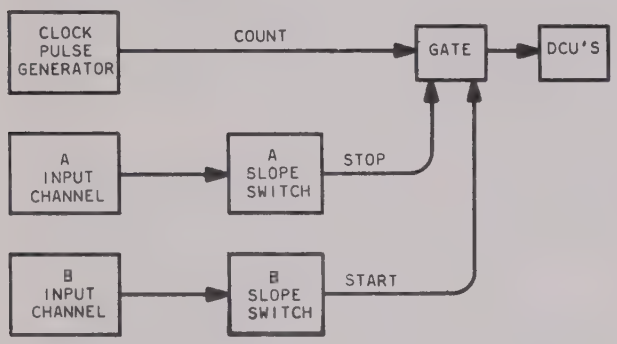


FIGURE 4d

To make a measurement proceed as follows:

1. Connect the start signal to the START INPUT and the stop signal to the STOP INPUT. (See "COUNTER INPUT ADJUSTMENTS" above.)
2. Rotate the FUNCTION switch to TIM. In this position the B SLOPE selects the polarity of the voltage excursion which begins the timing period. The A SLOPE switch selects the polarity of that which ends the timing period.
3. Rotate the TIME switch to the desired unit of time measurement. For example, at the 10^{-4} position the time measurement appears in ten-thousandths of a second. The smaller the time unit chosen, the more accurate the reading.
4. Adjust the DISPLAY time control to a position at which the count on the lighted DCU's may be read conveniently.
5. To obtain a reading in seconds, multiply the count on the DCU's by the factor to which the TIME switch is set.

PERIOD Operation

At the PER position of the FUNCTION switch the unit measures the time interval between consecutive voltage excursions through a selected level at the B INPUT. This setting may be used to measure the period of a wave or the width of a pulse. The major components are connected as **in Figure 4e.**

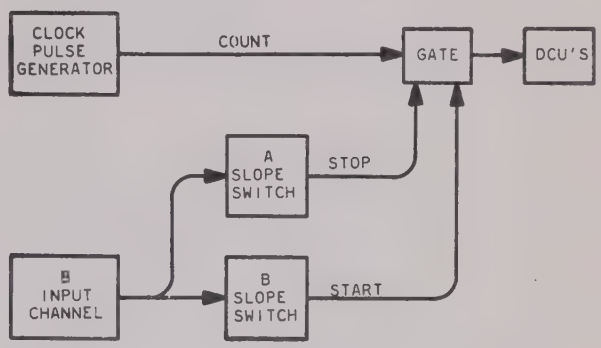


FIGURE 4e

To make a measurement proceed as follows:

1. Connect the wave or pulse source to the B (PERIOD) INPUT. (See "COUNTER INPUT ADJUSTMENTS" above.)
2. Rotate the FUNCTION switch to PERIOD. At this position the B SLOPE switch selects the polarity of the voltage excursion which begins the timing period. The A SLOPE switch selects the polarity of that which ends the timing period.
3. Therefore,
   (a) When measuring the period of a wave, set both SLOPE switches to "+" or both to "-".
   (b) When measuring the width of a positive pulse, set the B SLOPE switch to "+" and the A SLOPE switch to "-".
   (c) When measuring a negative pulse, set the B SLOPE switch to "-" and the A SLOPE switch to "+".
4. Follow steps 3, 4 & 5 under "TIM Operation".

PERIOD x 10 Operation

The unit measures the time interval between a voltage excursion through a selected level at the B INPUT and the tenth following excursion. This setting will measure the period of a wave more accurately than the PERIOD operation. The major components are connected as diagramed in Figure 4f.

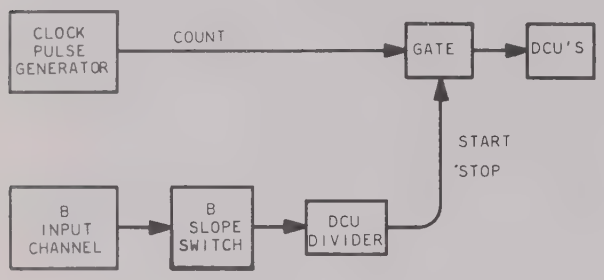


FIGURE 4f

To make a measurement proceed as follows:

1. Connect the wave source to the B (PERIOD) INPUT. (See "COUNTER INPUT ADJUSTMENTS" above.)
2. Rotate the FUNCTION switch to PFRIOD x 10. The B SLOPE switch selects the polarity of both start and stop voltage excursions.
3., 4 & 5. Follow steps 3, 4 & 5 under "TIM Operation".
6. Divide the reading by 10 to obtain the length of one period.

COUNT Operation

The unit counts the input to the B channel during the period the FUNCTION switch is in the COUNT Position.

1. Connect input to B channel. (See "COUNTER INPUT ADJUSTMENTS" above.)
2. Turn FUNCTION switch to OFF.
3. Depress manual RESET button.
4. Twist FUNCTION switch to COUNT to begin counting.
5. Twist FUNCTION switch to OFF to stop counting.

GATE Operation

This operation is a variation of TIM operation. Pulses generated by an external signal are substituted for internal clock pulses. The instrument counts cycles of the substituted signal between a voltage excursion through a selected level as the B (START) INPUT and a voltage excursion through an independently chosen level at the A (STOP) INPUT.

The substituted signal must have an amplitude of 3 volts rms into a 7K load. Its frequency may be as high as 1MC. Couple the signal to the FREQ. jack at the rear of the counter and place the EXT-INT switch at EXT.

NOTE: The .01 μf capacitor (C401) connected between the FREQ. jack and the input circuit used for this operation is not large enough to pass frequencies lower than 10KC. If the external signal frequency is lower than 10KC, jumper this capacitor and connect a larger capacitor between the signal source and the FREQ. jack.

Rotate the TIME switch to 10^{-6}. Place the FUNCTION switch at TIM. Adjust the START and STOP input channels as described under "INPUT ADJUSTMENTS". See "TIM Operation" to learn how the SLOPE switches operate on these channels. The shaper stage of the clock pulse generator is used as the input trigger channel for the signal introduced at the FREQ. jack. Adjust the input trigger voltage of this channel with the SHAPER LEVEL control located on the top side of the counter chassis. Rotate this control to find the limits of the range in which the instruments counts. Set the control at the center of this range.

USING AN EXTERNAL REFERENCE FREQUENCY

An external reference frequency may be substituted for the internal oscillator signal. Introduce the external signal as described under "GATE Operation," but place the TIME switch at a position which produces a clock pulse frequency equal to the reference frequency divided by the desired power of 10.

REMOTE CONTROL OF OPERATING CYCLE

The counter can be controlled from a remote location so that it will not reset and begin another count until desired. Set the DISPLAY time control at a minimum and string a lead from the remote location to Pin 40 of the DIGITAL RECORDER socket. As long as this lead is grounded the counter will not reset. If a count is complete, then within 40 milliseconds after the lead is ungrounded the counter will have reset and be ready to start counting when a start pulse appears. As soon as the counter has reset, the lead may be grounded again or left ungrounded. It will not affect the operating cycle until the time arrives for the next automatic reset. At that time it must be grounded again to prevent reset.

ACCURACY

Measurements are subject to four important sources of error.

1. Counts missed or added as the Gate opens and closes.
2. Clock signal inaccuracy.
3. Errors in the time a start or stop pulse is triggered.
4. Counts missed because they occur during the resolution time of the counting circuits.

1.

Pulses which occur simultaneously with the opening or closing of the Gate may or may not be counted. This causes all measurements to vary plus or minus one count. The following equation defines the possible error introduced.

$$\text{(1) Max. \% error} = \frac{1}{\text{Count Indication}} \times 100.$$

Notice that measurements set up to yield the highest count indication will be most accurate.

The frequency of a sine wave signal can be measured directly by counting events-per-unit-time or indirectly by measuring the length of one period and calculating the frequency. Higher frequencies yield the highest count indication when measured directly, that is, using the E/UT or E/UT x 10 function. Lower frequencies produce the highest indication when rapid time signals are counted over one or ten periods - that is, using the PERIOD or PERIOD x 10 function.

Frequencies above 1KC produce the highest count indication when measured using the E/UT x 10 function and a 10-second time interval; frequencies below 1KC yield the highest count when measured with the PERIOD x 10 function and a 1 μsecond unit of time measurement. The accuracy achieved using alternative functions at various frequencies is graphically illustrated in Figure 6. Note that the curves for E/PUT x 10 (10-second interval) and PERIOD x 10 (1 μsec time unit) cross at 1KC. This frequency cannot be measured with a possible error less than .01%. Frequencies above and below may be measured with greater accuracy.

2. All measurements requiring a time signal (i.e. all measurements except A/B, A/B x 10 and COUNT) are subject to an additional error introduced by variations in the oscillator frequency. The oscillator frequency is stable to 2 parts in 10^{-7} per week, so it can cause a maximum error of only .00002%.
3. Measurements using a external signal to trigger start and stop pulses (i.e. PERIOD, PERIOD x 10, TIM, A/B and A/B x 10) may be subject to a further error caused by pulses which are triggered too soon or too late. Refer to Figure 5 which illustrates what occurs during a simple period measurement.

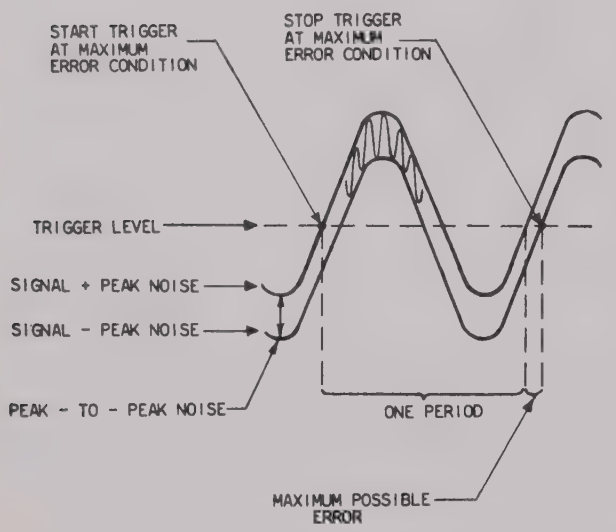

START TRIGGER AT MAXIMUM ERROR CONDITION
STOP TRIGGER AT MAXIMUM ERROR CONDITION
TRIGGER LEVEL
SIGNAL + PEAK NOISE
SIGNAL - PEAK NOISE
PEAK - TO - PEAK NOISE
ONE PERIOD
MAXIMUM POSSIBLE ERROR

FIGURE 5. EFFECT OF NOISE ON ACCURACY OF PERIOD MEASUREMENTS

Consider the total signal as an ideal signal intended to trigger the input channel plus a noise signal. The noise voltages added or subtracted from the ideal signal may trigger a pulse before or after the instant at which counting should begin or end. The maximum error in the time of triggering will be proportional to the noise amplitude and inversely proportional to the slope of the ideal signal at the trigger level. Expressed mathematically,

$$(2)\ t\ (\text{secs}) = \frac{V_n\ (\text{volts})}{S\ (\text{volts/sec})}$$

where t = Max. error in trigger time

V_n = peak-to-peak noise

S = slope of ideal signal at trigger level

The total noise (V_n) is equal to that carried by the input signal after attenuation plus that internally generated by the input channel. The internal noise (which takes the form of amplifier drift, trigger level jitter, line frequency pick-up, etc) is not more than 300 microvolts. Note that as the amplitude of of the input signal is increased, S in equation (2) becomes larger and the internal noise causes less error.

The percentage error may be calculated by dividing the error in trigger time by the counting period and multiplying by 100. In the common case of a period measurement of a sine wave triggering at its zero crossover value:

$$(3)\ \text{Max. \% error} = \frac{V_n\ (\text{volts})}{V_s\ (\text{volts}) \times \pi} \times 100$$

where V_n = peak-to-peak noise

V_s = peak-to-peak signal

The maximum percent error of a PERIOD x 10 measurement is one-tenth the value given in equation (3).

The total error due to the three causes mentioned above is equal to the sum of the separate errors.

Total Max. percent error equals:

$$\frac{100}{\text{Count Indication}} + .00002 + \text{Percent error due to noise}$$

↓ If E/UT, E/UT x 10, PERIOD, PERIOD x 10 or TIM

↓ If PERIOD, PERIOD x 10, TIM, A/B or A/B x 10

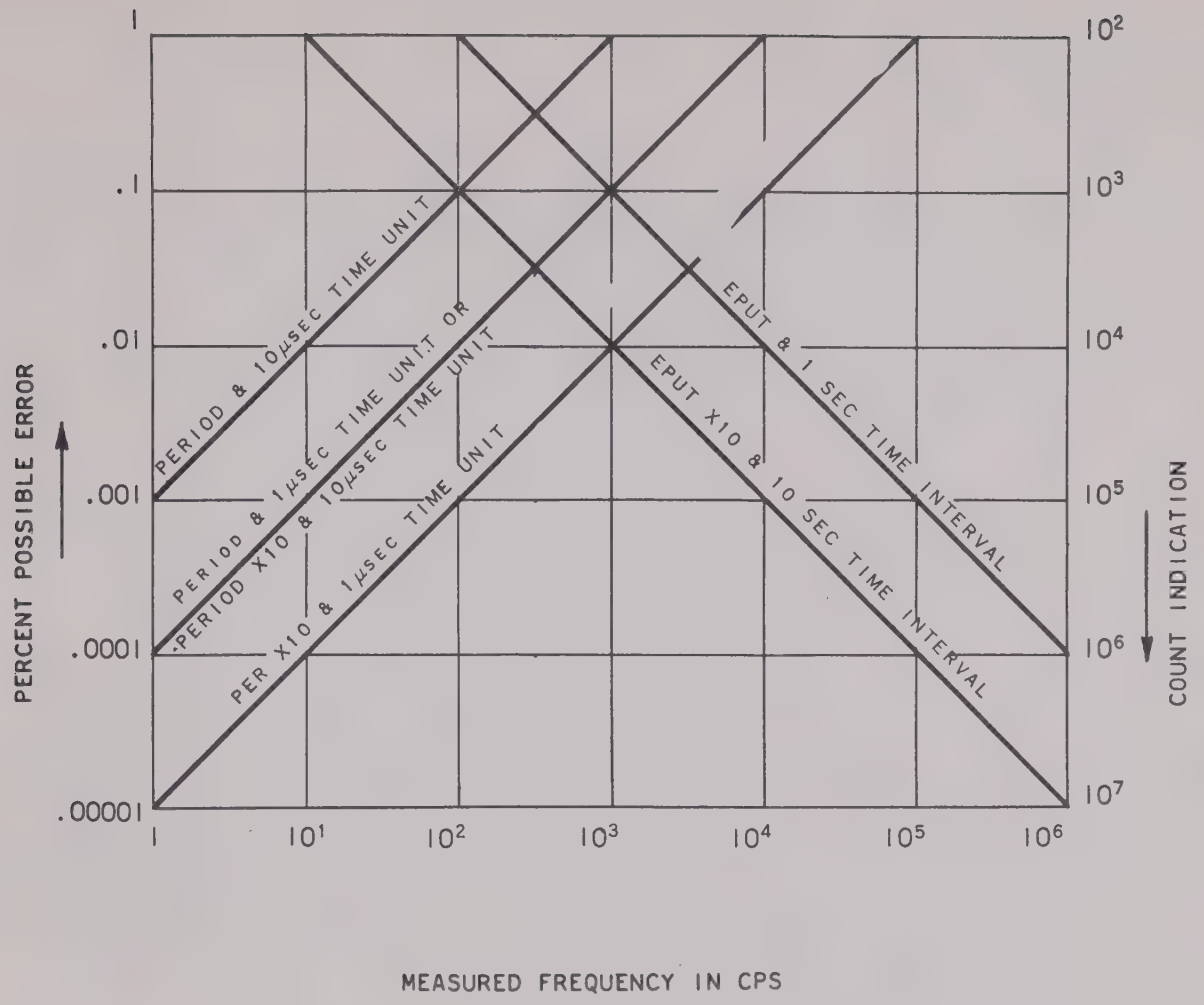


FIGURE 6. ERROR DUE TO ±1 COUNT LIMITATION

4. Another source of error becomes important when random events are counted. One such event may occur immediately after another, before the counting circuits are fully recovered and prepared to register it. The second event will not only fail to cause a count but its effect on the circuitry may cause a third event to fail to register also. Formulae for calculating the counting error due to this effect may be found in "Application of Probability Theory to Nuclear Particle Detection", L. J. Rainwater and G. S. Wu, Nucleonics, October 1947. The minimum time which must elapse between events if both are to be counted is called resolution time of the instrument. The Model 5571-1 has a resolution time of .5 μseconds or better.

AUXILIARY CONNECTORS

DIGITAL RECORDER Jack

Each DCU generates a 4-line code representing the digit it is displaying. These lines are collected at the DIGITAL RECORDER socket at the rear of the instrument. The Model 1452 Digital Recorder plugs directly into this socket. The socket also makes mutual control connections between the counter and the recording device.

TIME Jack

The output signal of the clock-pulse generator is available at this jack. The signal consists of positive pulses 2.5 volts in amplitude. The positive transients are accurately spaced at the interval indicated by TIME switch. These transients are recommended for external use as a clock signal. The negative transients occur at the same frequency but are not so accurately spaced. The output impedance is 330 ohms.

FREQ Jack

A sine-wave signal at the oscillator frequency is available at this jack when the EXT-INT switch is at INT. The signal is 10 volts peak-to-peak out of 3000 ohms. When the EXT-INT switch is at EXT., an external signal can be introduced at this jack to substitute for the oscillator signal as described under "GATE Operation".

SCOPE Jack

This jack is connected thru 220K to the suppressor grid of the gate tube. The voltage on this grid determines whether the gate is "open" or "closed". The voltage at the jack is about ground level when the gate is open and about -22 volts with respect to ground when the gate is closed. If the waveform of a signal generating start-stop pulses is displayed on an oscilloscope, the signal at the SCOPE jack may be used to blank the scope during the period the gate is closed. The scope will then display the portion of the waveform whose length is being measured.

ACCESSORY Jack

This socket provides connections to +120 VDC regulated at 10 ma, -110 VDC at 15 ma, +190 VDC at 20 ma and 6.3 VAC at 2 amperes. These supplies may be used to power auxiliary equipment such as transducers. The power supply schematic shows at which terminal each supply is available.

3 Circuit description

NOTE: It is intended that the reader refer frequently to relevant schematic diagrams while reading the material in this section. The Decimal Counting Units are described in an appendix.

GATE & CONTROL CIRCUITRY

The Gate and control Circuitry receive three pulse inputs from the FUNCTION switch (S201): pulses to be counted, start pulses and stop pulses. Pulses to be counted go from Deck G to the signal grid of the Gate tube (V204). The plate of this tube is coupled to the first of the cascaded DCU's. During the period its suppressor grid is at ground the tube amplifies the grid signal and drives the DCU's. In this state the Gate is "open". When the suppressor grid is below -10 volts, the tube is cut off and the Gate may be considered "closed".

The "open-close" voltages on the Gate tube suppressor grid are generated at the right plate of the Control Binary (V203). V203 is a conventional "flip-flop" circuit. Such a circuit has two stable states: left half conducting, right half cut off; and right half conducting, left half cut off. Input pulses or transients applied at various points on the circuit will trigger it back and forth between the two states. When the right half of V203 is conducting, the right plate is 30 volts negative. A negative start transient from the Start Binary, applied at the left plate of V203 and coupled through C210 to the right grid, triggers V203 to its other stable state. In this state the right half is cut off and the right plate rises above ground permitting the Gate tube to conduct.

When a negative stop pulse from Deck E of the FUNCTION switch reaches the left grid of V203 through the diode V201B, V203 is triggered back to the state which holds the Gate closed.

The Start Binary is also a "flip-flop" circuit. It produces a negative start transient at its right plate each time that half begins to conduct. Its left grid is coupled to Deck C of the FUNCTION switch through the diode V201A and C201. When the left half is conducting a negative start pulse at the grid triggers a change to the other stable state producing the output transient. Further negative pulses at the left grid have no effect since that half is already cut off.

When the instrument is ready to begin a counting period the right half of the Control Binary and the left half of the Start Binary are conducting and the Gate is closed. Negative stop pulses received at the left grid of the Control Binary have no effect since this half is cut off. The following sequence occurs. (Refer to Figures 7 & 8).

Time (1) A start pulse passes through the injection diode V201A and triggers the Start Binary which in turn triggers the Control Binary to a state which opens the Gate. The DCU's then

count and indicate the number of pulses reaching the Gate.

Time ② A stop pulse triggers the Control Binary to a state which closes the Gate.

At this point, if the instrument is set to operate automatically, the reset circuitry begins to function. The reset control voltage appears at the junction of CR201 and CR203. Its value is determined by the combined effect of the voltage on the right plate of the Start Binary and that on the right plate of the Gate Control Binary. At the close of a counting period (and only then) both these plates are negative. The resulting negative voltage at the junction is applied to the input grid of the Reset Generator through R239.

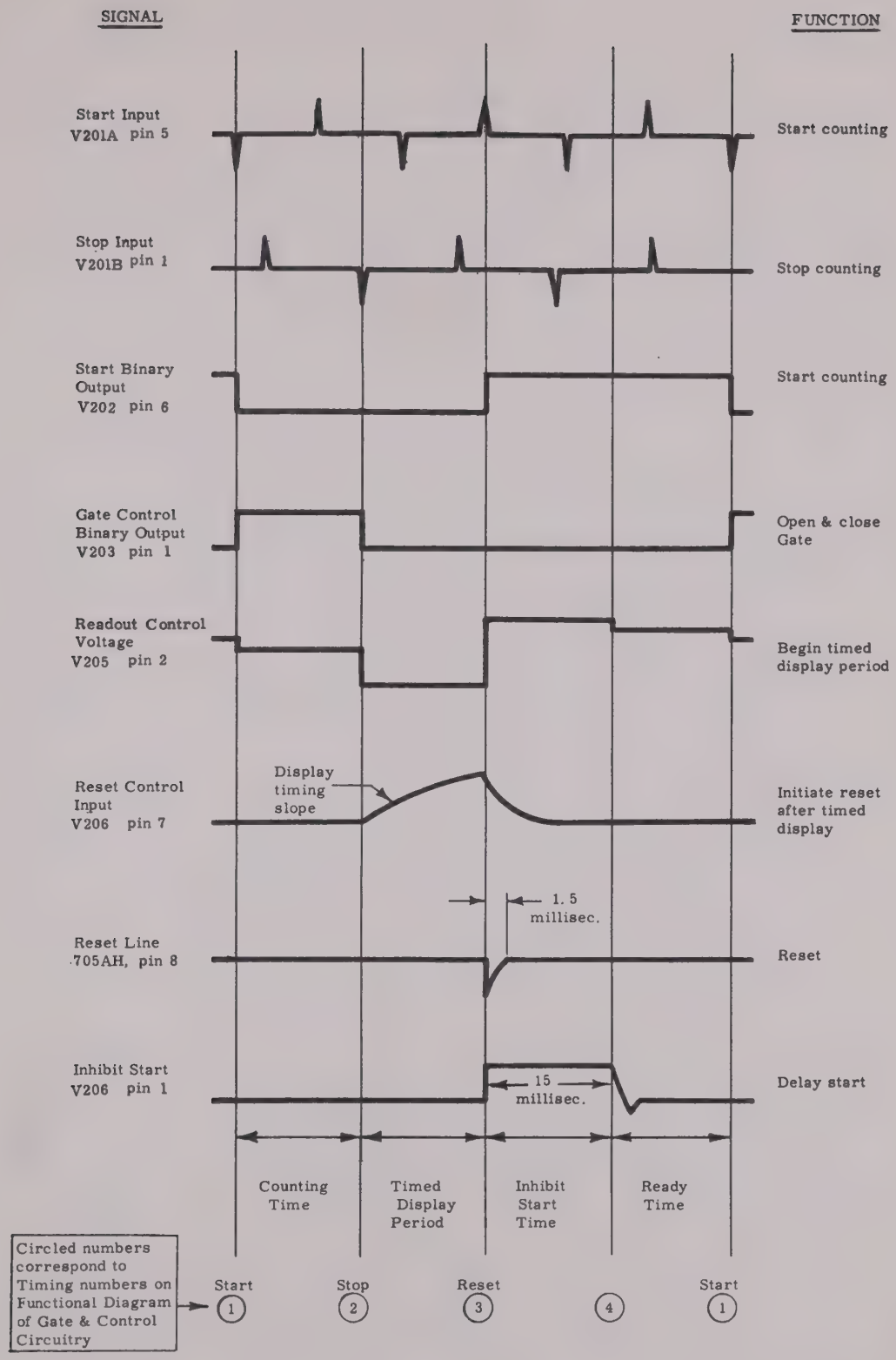
The Reset Generator (V205) is a two stage amplifier. The first stage (the left half) is a voltage amplifier. The second stage is a cathode follower. The Reset Generator performs two functions. It amplifies the reset control voltage at time ② and it produces a reset pulse upon receiving a signal from the Reset Control at time ③. The negative reset control voltage is amplified, inverted and coupled from the output cathode to the DISPLAY time potentiometer (R247) through R244, CR206 and S204. The positive charge at R247 leaks onto C126. C216 is coupled to the input grid of the Reset Control (V206) through S205B. When this grid rises above a certain voltage, V206 generates an output pulse which initiates step 3 , the reset action.

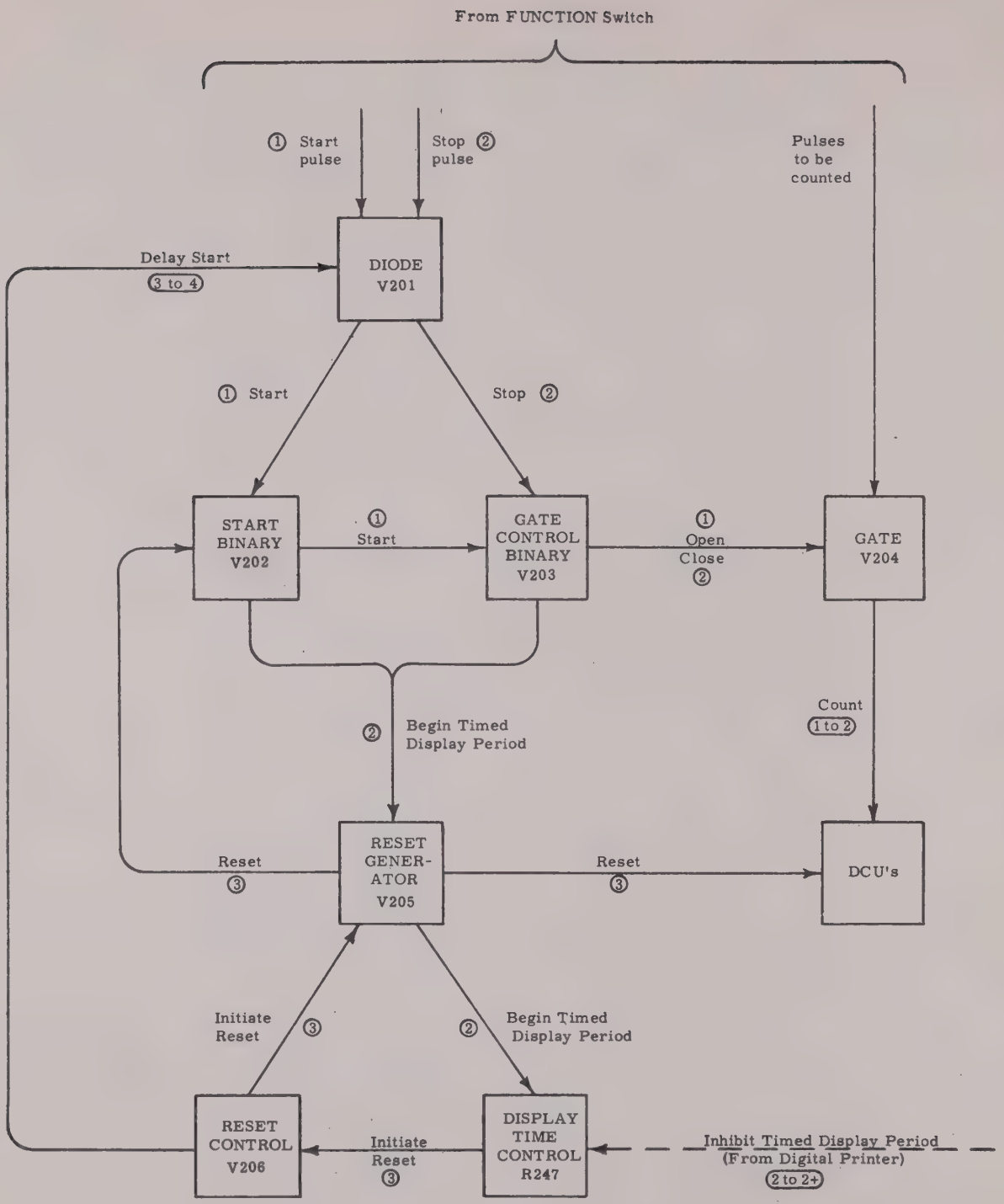
The Reset Control is a monostable mutlivibrator. In its stable state the right triode is conducting and the left triode is cut off. When the left grid becomes sufficiently positive, that half begins to conduct and right side is cut off momentarily by a negative pulse produced at the left plate and coupled to right grid by C218. The output is a positive pulse at the right plate.

This positive pulse is coupled through R236 and R239 to the input grid of the Reset Generator producing a negative transient at the plate of the first stage which resets all the DCU's and Start Binary. The positive pulse from the Reset Control is also coupled to the cathode of the Start Binary injection diode by R212, C203 and R209. The positive charge on the cathode prevents negative start pulses from reaching the Start Binary until all reset transients have decayed. At time ④, about 15 milliseconds after the reset pulse, the control circuitry is ready to accept another start pulse.

NOTE: When the counter is equipped with the Model 1452 Digital Recorder, the sequence of operations described above is interrupted briefly. A relay in the recorder grounds the input to the DISPLAY time potentiometer from the end of the counting period (time ②) until the recorder has collected count information from the DCU's. (See Figure 9). The connection to the recorder is made through pin 40 of J202.

When the DISPLAY time control is turned fully clockwise the input connection to this potentiometer is broken by S204 and the automatic reset action will not occur. The DCU's hold the accumulated count until the manual RESET button is depressed. Depressing this button actuates S205A and S205B. S205A connects the -110 volt supply to the Reset Generator input grid. S205B connects C216 to the output cathode of the Reset Generator which is then at a high positive voltage. When the button is released the positive charge on C216 flows onto the Reset Control grid and initiates the same reset action that occurs under automatic operation.


SIGNAL
FUNCTION
Start Input V201A pin 5
Start counting
Stop Input V201B pin 1
Stop counting
Start Binary Output V202 pin 6
Start counting
Gate Control Binary Output V203 pin 1
Open & close Gate
Readout Control Voltage V205 pin 2
Begin timed display period
Display timing slope
Reset Control Input V206 pin 7
Initiate reset after timed display
1.5 millisec.
Reset Line 705AH, pin 8
Reset
Inhibit Start V206 pin 1
15 millisec.
Delay start
Counting Time
Timed Display Period
Inhibit Start Time
Ready Time
Circled numbers correspond to Timing numbers on Functional Diagram of Gate & Control Circuitry
Start
Stop
Reset
Start
1
2
3
4
1



NOTE: Circled numbers indicate time of operation as labeled on the Timing Diagrams.

Figure 8 Functional Diagram of Gate and Control Circuitry

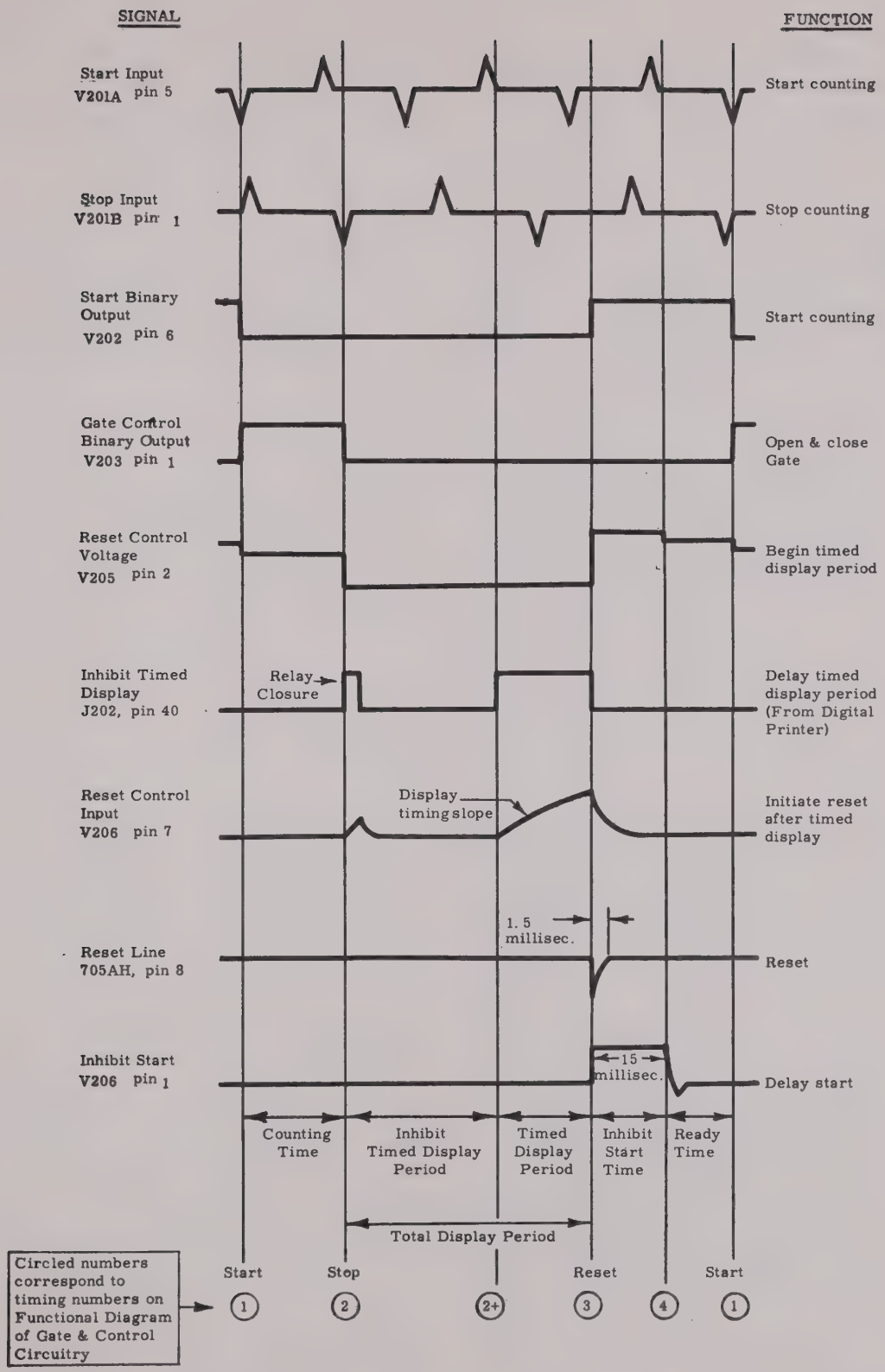


Figure 9 Control Circuit Timing Diagram

WHEN COUNTER IS EQUIPPED WITH DIGITAL PRINTER

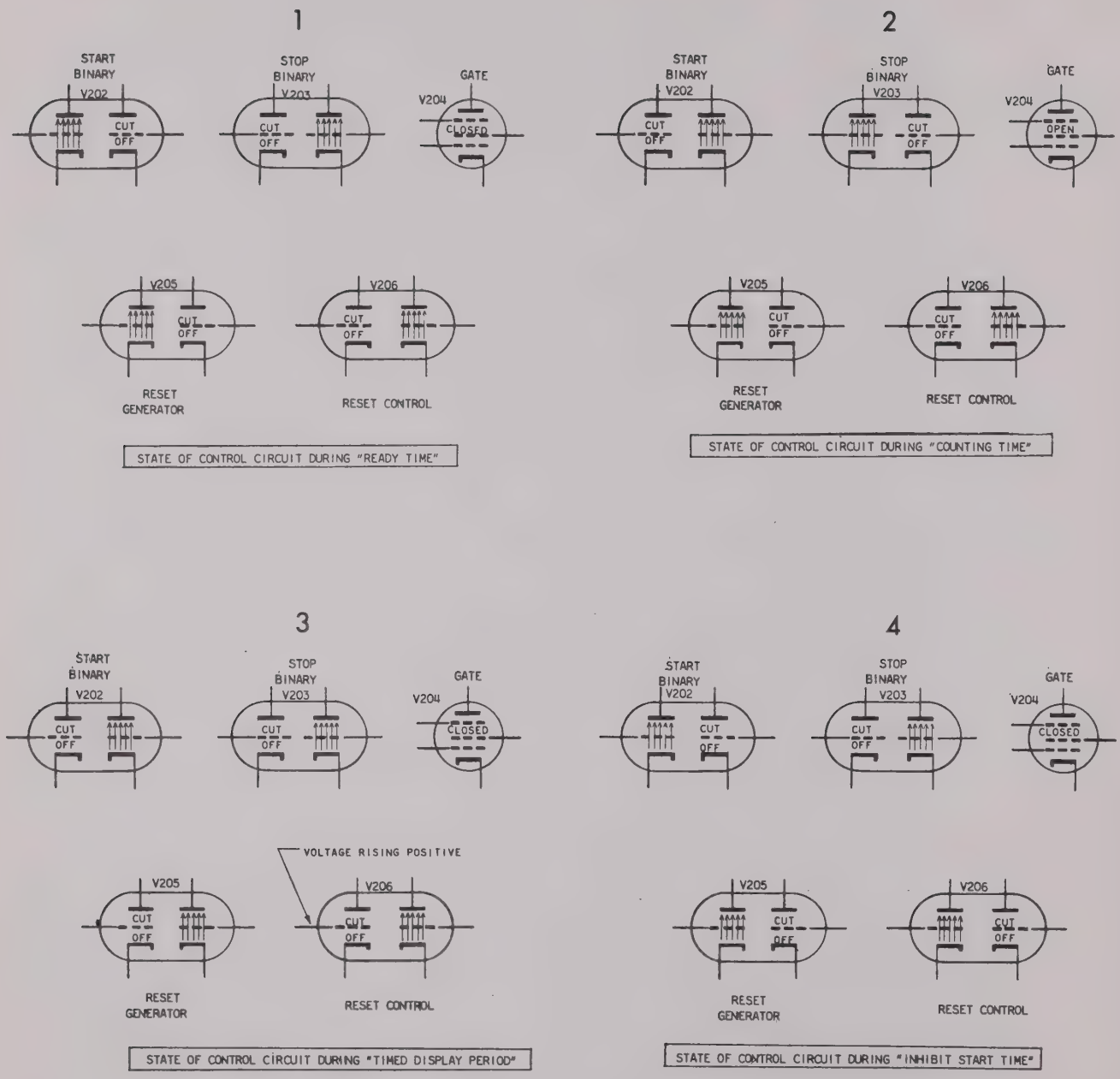


Figure 10 Tube States During the Operating Cycle

INPUT TRIGGER CHANNELS

The input trigger channels are similar. The following discussion applies to the A channel. The B channel operates in the same way except that a cathode follower has been inserted between the comparator amplifier and the voltage discriminator.

Each channel produces and output pulse each time the attenuated input signal passes a selected voltage level. The output is independent of input waveform. The channel consists of a Schmitt trigger voltage discriminator preceded by a two-stage comparator amplifier. Each input channel is preceded by an attenuator, which divides the input voltage by 1, 10 or 100 according to the position of the ATTENUATION control. The input impedance at all positions is about 10 megohms in parallel with 40 $\mu\mu$f. When the ATTENUATION control is at an AC position a .01μf capacitor (C201) is inserted in series between the INPUT jack and the attenuator.

The comparator amplifier has two stages. The first is a difference amplifier whose output is portional to the input voltage on the grid of V301A minus a selected constant voltage on the grid of V301B. The TRIGGER VOLTAGE potentiometer (R318) varies the voltage on the grid of V301B between -1 and +1 volts. The second stage (V302) amplifies the double-ended signal received from V301 and converts it to a single-ended low impedance output at the left hand plate. This plate is connected to the input grid of the discriminator.

The voltage discriminator (V303) produces an output pulse each time the input voltage on its left-hand grid passes through a fixed voltage level (about+60 volts). Consider the input to this circuit as an a-c triggering signal superimposed on d-c level. The a-c signal is an amplified reproduction of the voltage variations on the grid of V201A, that is, the attenuated input. The d-c level is determined by the voltage on the grid of V301B, a voltage set by the TRIGGER VOLTAGE potentiometer. As the TRIGGER VOLTAGE pot is rotated toward "+", the d-c level is lowered and the discriminator triggers at a higher instantaneous voltage of the a-c signal and at a higher attenuated input voltage to the channel. When the TRIGGER VOLTAGE control is turned toward "-", the channel triggers at a lower attenuated input voltage.

The discriminator (V303) is a two stage positive feedback amplifier. Feedback from the output stage occurs through the cathode coupling. The loop gain is slightly greater than one so that the circuit is regenerative and tends to assume one of two stable stages. The output stage draws a steady current as long as the input grid remains below a certain triggering voltage. When the input exceeds this voltage the output tube is suddenly cut off. When the input voltage returns to a value slightly below the initial triggering voltage the output stage builds rapidly to its original steady current.

The difference between the level at which a positive-going voltage change triggers the circuit and the lower level at which a negative-going voltage change re-triggers it is called the hysteresis of the circuit. At the input to the comparator amplifier the hysteresis is about 0.3 volts. The hysteresis determines the input sensitivity. An attenuated input signal weaker than 0.3 volts peak-to-peak or about 0.1 volts rms will not trigger a series of pulses. This means that any noise at the attenuated input below this level will not trigger extraneous pulses, although it may affect the time at which a pulse occurs.

The primary winding of T301, differentiates the rapid current changes in the output stage to produce a positive pulse at the plate when the circuit is triggered by a positive-going voltage and a negative pulse when triggered by a negative-going voltage. The secondary of T201 produces inverted pulses - - a negative pulse when the circuit is triggered on a positive slope and a positive pulse when triggered on a negative slope.

DCU DIVIDER

Deck A of the FUNCTION switch (S201A) selects the signal which is divided by the DCU Divider (AY 201). During all operations other than "times ten" (x10) operations the output of the last 705AH DCU (AY 202) is coupled to the input of this divider and it functions as the last in the chain, raising the maximum count indication to 10,000,000.

During "times ten" operations the source of "start-stop" pulses is coupled to this divider through a two stage amplifier (V207), and the output of the divider becomes the "start-stop" input to the Control Circuitry. Since it produces an output pulse at every tenth input pulse, the time interval during which pulses are counted is ten times as large as it would be if the source of "start-stop" pulses drove the Control Circuitry directly. This DCU will not divide a frequency above 100 KC because its pulse resolution time is about 10 μseconds.

When the divider is part of the counting chain, Deck B of the FUNCTION switch (S201B) couples the reset pulse to pin 8 of the DCU Plug so that it resets to zero. During "times ten" operations Deck F of the FUNCTION switch connects pin 10 to -15 volts to extinguish the DCU indicator lamps and Deck D couples the reset pulse to pin 3 causing the divider to reset to nine. This is done so that the counting period will begin with the first input pulse rather than the tenth, thus eliminating an unnecessary delay.

CLOCK-PULSE GENERATOR

The Clock Pulse Generator provides

1. Pulses of a known frequency which are counted between start and stop pulses to make time measurements.
2. Start and stop pulses separated by a known time interval over which events are counted to make events-per-unit-time measurements.

The circuitry consists of an oscillator, a pulse-shaping circuit, a series of multivibrator frequency dividers, and an output trigger circuit. An additional dividing stage, the DCU Divider, is available to provide a 10-second counting period for E/UT x 10 and SCAN measurements. The shaper stage transforms the sinusoidal output of the oscillator into appropriate pulses. Each of the dividers divides the preceding frequency by ten. Decade frequencies from the shaper and the various dividers are selected by the TIME switch, shaped by the output trigger circuit (the Time Pulse Trigger) and applied to the FUNCTION switch, where they are available for start, stop or pulses to be counted.

OSCILLATOR

A crystal controlled oscillator provides a 1MC reference frequency which is divided to obtain clock pulses of various frequencies. The oscillator consists of a two-stage amplifier with a Wheatstone bridge feedback circuit. The first stage (V401B) is a triode with an L-C tuned plate load. The triode operates as a voltage amplifier and drives the second stage V401A, a pentode which operates as a cathode follower power amplifier.

Feedback is taken from across the cathode load resistors of the pentode and fed to the inputs of a Wheatstone bridge in the cathode-grid circuit of triode. The upper arms of the bridge, consisting of R440, crystal Y401, C409 and C410, supply negative feedback to the triode grid. The lower arms consisting of RXXX and a non-linear resistor (the thermistor I401) supply positive feedback to the triode cathode. As the amplitude of the triode plate signal increases, the pentode supplies more

power to the bridge and the current through the thermistor increases raising its resistance. The higher resistance alters the voltage dividing ratio of this arm of the bridge so that less positive feedback is applied to the cathode and the amplitude of the triode plate signal is lowered. This action provides great frequency stability by limiting the amplitude of oscillation to the linear range of the circuit.

The crystal is tuned with the temperature stable capacitor C410. By adjusting the capacitor the output frequency may be shifted as much as .001%. The impedance of the crystal (Y401) varies from unit to unit. The value of RXXX has been chosen at the factory so that the voltage dividing ratio of the bridge will produce the proper amount of feedback. The triode plate circuit (L401, C403) is tuned to resonance at the oscillator frequency.

SHAPER

The shaper stage (V402) amplifiers and shapes the oscillator output for use as an input to the control circuitry and the dividers. The circuit is a voltage discriminator which operates in the same way as that discussed under "Input Trigger Channels". The trigger voltage level is set by adjusting R414. L402 differentiates the rapid current changes at the output plate to produce fast positive and negative pulses. The negative transients drive the first divider through the twin diode V602. The pulse output is conducted to the TIME switch (where it may be selected to drive the Time Pulse Trigger) and directly to the FUNCTION switch where it provides pulses to be counting during the TEST operation and a start pulse for the COUNT operation.

DIVIDERS

The dividing chain consists of six cascaded monostable multivibrators. Each produces one output pulse for every ten input pulses. Although the 1MC divider (V501, V502) carries additional circuitry to fit it for high-speed operation, it operates in essentially the same way as the others. The action is described with reference to V604. With no input the circuit is stable; the right-hand side is conducting because its grid is connected to +120 VDC and the left-hand side is cut off. A negative transient reaching the input capacitor (C605) is coupled through R617 and R618 to each of the two plates. The negative pulse produced on the left plate is coupled by C609 to the right grid. It appears as an amplified positive pulse at the right plate, which is coupled to the left grid through C607. The left-hand side of the tube conducts, driving the left plate and the right grid even further negative. This regenerative action produces a quasi-stable stage in which the right side is cut-off and the left side is conducting. In this state the voltage on the right grid (called the "timing grid") is rising relatively slowly as the voltage at the wiper of potentiometer R656 charges the timing capacitor (C609) through R 645. At the same time negative input pulses at the right plate reach the left grid through C607 and appear as large positive pulses at the left plate. These pulses reach the timing grid through C609 and appear superimposed on the rising voltage curve there. (See Figure 11). When one of the positive pulses brings the timing grid above cut-off, the right side conducts and a reverse regenerative action returns the circuit to its original stable state. The slope of the rising grid voltage curve determines which of the successive positive pulses will rise above cut-off. The slope changes when the charging voltage at the wiper of R656 is raised or lowered. R656 is adjusted so that the ninth pulse rises above cut-off. The tenth pulse returns the circuit to the quasi-stable state.

In the interval between the ninth and tenth pulses the right side is conducting and the right

plate is negative. The negative transient produced is the useful output of the divider. It drives the next divider stage through C609 and is conduced to the TIME switch where it is available as a clock signal.

The additional circuitry associated with the 1MC divider (V501) speeds up its response. V501 is a multivibrator which operates just as V604. V502A is a cathode follower inserted between left plate of the multivibrator and timing grid. Its function is to discharge C504, the timing capacitor, within the brief 1 μsecond output pulse period so that the capacitor will pass the next positive pulse to the grid. V502B functions as a diode clamp on the left grid of the multivibrator. It prevents this grid from going so far negative during the 1 μsecond pulse output period that it will not rise above cutoff when the next positive pulse reaches it.

TIME PULSE TRIGGER

The TIME switch selects a negative output transient from one of the dividers stages and feeds it to the Time Pulse Trigger (V601). The Time Pulse Trigger is a voltage discriminator which operates in the same way as that described under "Input Trigger Channels". Output clock pulses produced at L601 are coupled to the FUNCTION switch.

POWER SUPPLY

A conventional system consisting of a transformer, two selenium bridge rectifiers and a filter network produces the +190 and -110 volt unregulated supply. Ripple on these supplies is about 10%.

The regulated +120 volt supply is obtained by dropping 190 volts through V102. The voltage drop across V102 is controlled by V101 in such a way as to maintain a constant voltage at the regulated output. A voltage dividing network (R106, R107 R113) is connected between the regulated supply and a point held 60 volts negative of ground by a

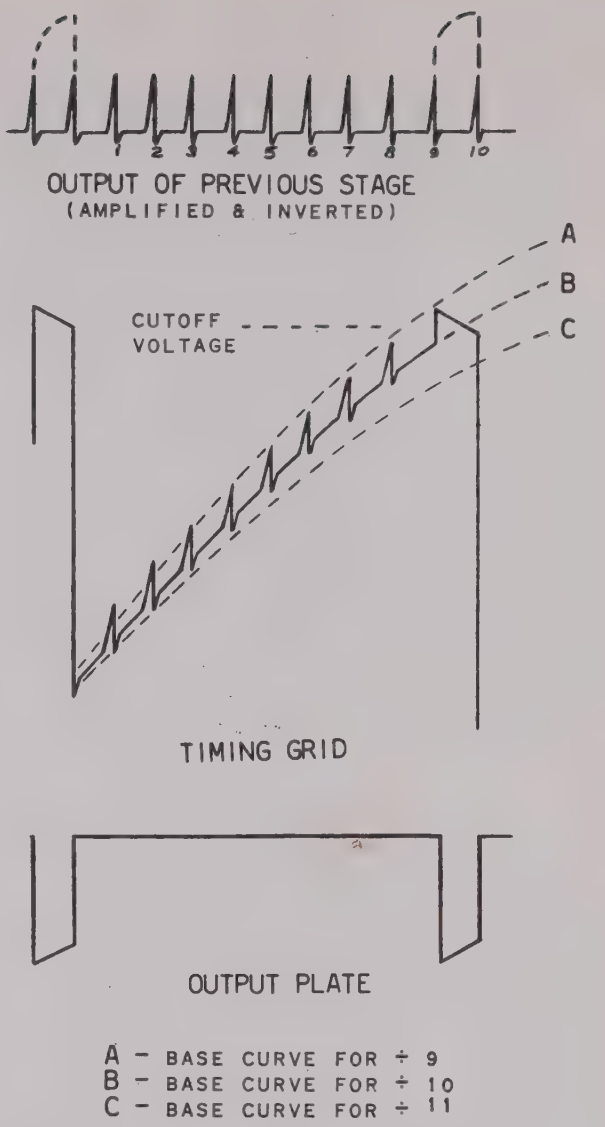


FIGURE 11. DIVIDER STAGE WAVEFORMS

diode (CR103). The control grid of V101 is connected to a point on this network which is slightly below ground when the regulated supply is 120 volts. When the regulated supply varies from 120 volts, the voltage on the control grid varies proportionately and V101 delivers a signal to V102 which opposes the change.

The -60 volts supply is shunt regulated by V104. Since this tube operates as a cathode follower the output voltage drawn from the cathodes remains very near the 60 volts maintained on the grids by the diode.

HETERODYNE UNIT

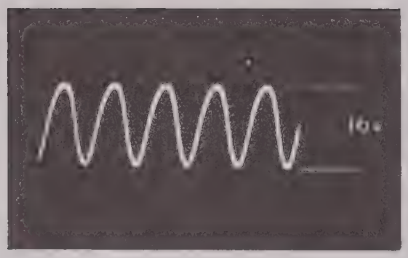
In the Heterodyne Unit a 1 MC signal from the oscillator in the clock-pulse generator drives a harmonic generator (V701, V702 & 703) which produces all the harmonics of 1 MC up to 41 MC. The reference frequency selector couples a circuit tuned to the desired harmonic to the output of the harmonic generator. This harmonic is fed to the mixer (V704) where it is beat against the signal to be measured. The beat frequency produced is amplified by V705 and fed to the counter.

The harmonic generator produces a narrow pulse of current at a repetition rate of 1 megacycle per second which excites a tank circuit tuned a harmonic of this frequency. The first stage (V701) amplifies the oscillator signal and isolates the oscillator from the succeeding circuitry. The next stage (V702) is grid current biased. This tube has a sharp cutoff and its input signal is so strong that the accumulated bias cuts it off for all but a small part of each cycle. The resulting brief pulse of plate current excites L702 causing it to "ring" or oscillate at about 10 MC. However, this oscillation is damped sufficiently so that only the first positive pulse is high enough to affect the next stage, V703. This stage is also grid biased and the amplitude of the pulse which drives it is great enough to bias it below cutoff during most of the pulse width. It draws a narrow 1 MC pulse of current which excites the tank circuit formed by L703 and the capacitor selected by the turret switch. The tank circuit is tuned to the harmonic frequency chosen by the FREQUENCY SELECTOR ; it oscillates at that frequency. A single turn loop (L704) couples the chosen reference harmonic to grid 3 of the mixer. A 1 MC series resonant trap (C718, L707) is connected between this grid and ground to filter out whatever 1 MC fundamental leaks through the frequency selector.

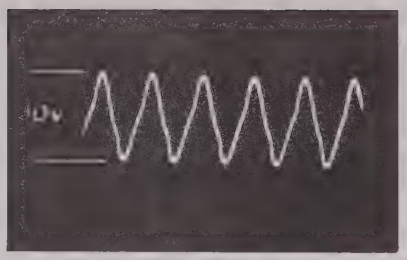
At frequencies below 10 MC the impedance of L703 becomes so small that the plate current pulse develops a comparatively slight voltage across the tank. To maintain the strength of the reference signal at these frequencies the output of V703 is increased by decreasing its grid bias resistance. This is done by mechanically coupling S700 to the turret switch so that the switch closes, shorting out R708, when the FREQUENCY SELECTOR is moved below 10 MC.

The signal to be measured is introduced at the INPUT jack (J700). It is passed through a high pass filter to remove low frequency noise which might otherwise reach the counter. The filtered signal is coupled to grid 1 of the mixer by the LEVEL ADJUST potentiometer (R714) which is adjusted to attenuate the signal enough to avoid driving grid 1 beyond its linear range. When grid 1 operated beyond its linear range the mixer will produce an output containing any modulation frequency which may be on the input signal. The BIAS ADJUST potentiometer (R720) sets the bias voltage on grid 3. This grid is adjusted to the center of its linear range. The output of the mixer passes through a low pass filter to grid 1 of the output amplifier (V705). The filter is adjusted to cutoff at about 1.2 MC. It blocks three of the signals which appear at the plate of the mixer: the reference frequency, the input signal frequency and their sum. Only the difference frequency reaches the output amplifier (V705). This stage is a voltage amplifier followed by a cathode follower. The signal between the output cathode and ground is about 100 millivolts when the LEVEL ADJUST control is set properly. The OUTPUT ADJUST potentiometer is set so that the amplitude of the signal at the OUTPUT jack is twice the minimal amplitude required to drive the counter.

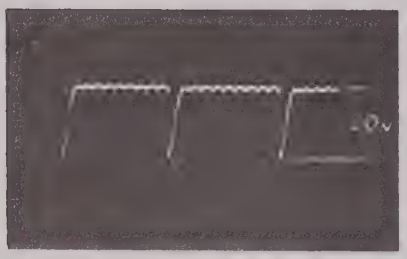
The metering circuit is connected from the output cathode to ground. The LEVEL meter (M701) will indicate the amplitude of any signal above 5 KC. If the instrument is operated correctly (i.e. at the lowest FREQUENCY SELECTOR position which deflects the meter to the green region) no beat frequency lower than 100 KC will be produced.



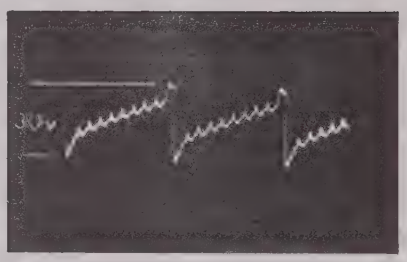
1. 1 MC Oscillator Output
V402, pin 2



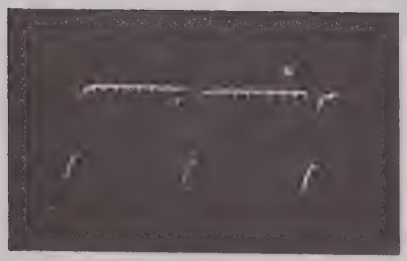
2. Shaper output, V402 , pin 1



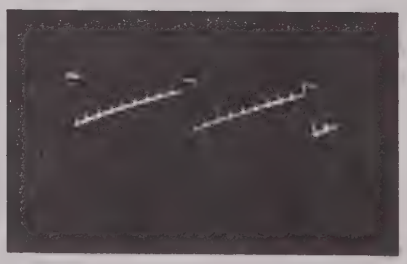
3. 1MC Divider Output Junction
of R502 and R503



4. 1MC Divider timing grid.
V501 pin 2

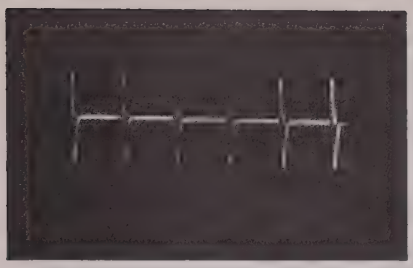


5. 100KC Divider Output
V603 pin 6

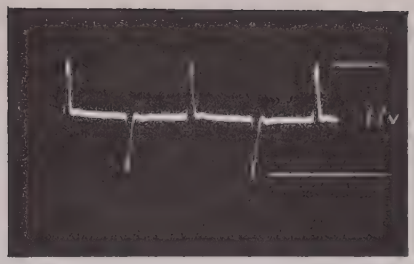


6. 100KC Divider, Timing Grid
V603, pin 7

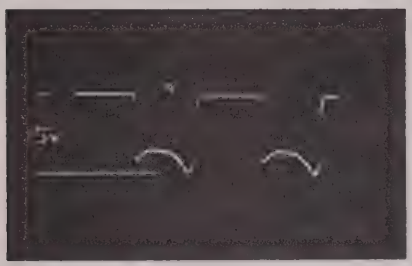
Figure 12a Typical Waveforms



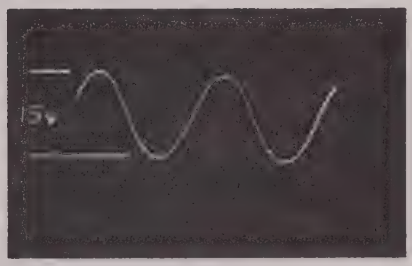
7. **Time Pulse Trigger**
100 KC output, V601, pin 1



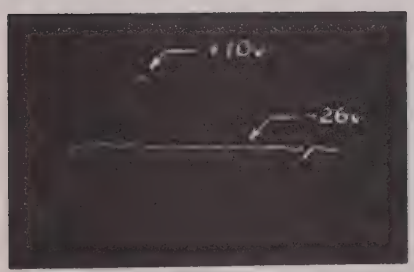
8. **Discriminator output**
V303, pin 1



9. **Discriminator amplifier plate.**
100 KC signal V303, pin 6



10. **Discriminator input. 100 KC**
signal, V303, pin 6



11. **Gate Control Binary output.**
V203, pin 1

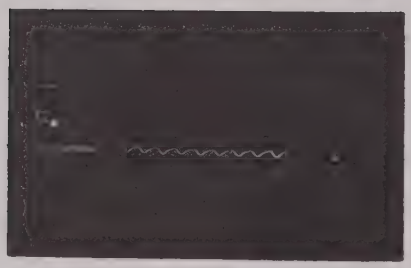
12. **Start Binary output.**
V202, pin 1

Figure 12b Typical Waveforms

14. **Reset pulse.** Junction of C218 and CR305

15. **Reset Control input.** V206 pin 7

16. **Reset Control output.** (minimum display time) V206 , pin 1



17. **Reset Control signal to Digital Recorder.** J202, pin 39

Figure 12c Typical Waveforms

4 Maintenance

ROUTINE ADJUSTMENTS

OSCILLATOR

The oscillator frequency can be varied by rotating the XTAL ADJust control on the top side of the counter chassis. Adjust the control until the oscillator signal which appears at the FREQuency jack comes to zero beat with a WWV signal or some other highly accurate frequency standard.

The oscillator is adjusted to maximum stability by a slug-tuned inductor (L401) in the plate circuit of the oscillator triode. L401 is located on under side of chassis near the SHAPER LEVEL potentiometer. Normally, an adjustment is required only when a tube or other component has been changed. Adjust the slug very carefully for a maximum signal at the FREQuency jack.

A third oscillator adjustment should be made whenever the crystal is replaced. Measure the signal at the FREQuency jack with a VTVM. Vary the resistance between the thermistor and ground by adding resistors in series or parallel with RXXX until the meter reads 4 volts rms.

SHAPER

The shaper stage in the clock-pulse generator is a voltage discriminator similar to those in the Input Trigger Channels. The SHAPER LEVEL control, located on the top side of the counter chassis, sets the trigger voltage at the input to this circuit. To adjust, set the FUNCTION switch at TEST. Find the limits of the range of adjustment in which the instrument continues to count. Set the control at the center of this range.

DIVIDERS

The dividers should be aligned occasionally by adjusting the potentiometer controls located on a narrow strip above the counter chassis and labeled ADJ. 1 SEC; ADJ 10^{-1} SEC; etc. Make the adjustments while the line voltage to the instrument is equal to the voltage it will be operated on. Place the FUNCTION switch at TEST. Then proceed as follows:

1. Turn TIME switch to 10^{-5} and measure the d-c voltage between test point E5 and ground. Rotate the ADJ. 10^{-5} SEC control to the extremes of the range in which a reading of 10 appears on the DCU's noting the test point voltage at each extreme. Then adjust the control until the test point voltage is midway between the extreme values.

2. Turn TIME switch to 10^{-4}. Measure voltage at point E4. Rotate ADJ 10^{-4} SEC control to extremes of range which reads "100", noting test point voltages at extremes. Adjust the control until the voltage is halfway between extremes.

3. With TIME switch at 10^{-3} set ADJ 10^{-3} SEC control similarly but to center of voltage range in which either 1000 or 999 appears.

4. Adjust the remaining controls in order to the center of the 10,000 or 9,999 range, the 100,000 or 99,999 range, and the 1,000,000 or 999,999 range.

The adjustment of each divider affects the adjustment of the others slightly. Therefore after the initial adjustment outlined above, a final adjustment should be made. With the FUNCTION switch at TEST, set the TIME switch to 10^{-1}.

A reading of 100,000 or 99,999 will appear. Adjust in turn ADJ 10^{-5} SEC thru ADJ 10^{-1} SEC to the center of the corresponding test point voltage range within which either of these readings appears. Then set the TIME switch at 1 and rotate ADJ 1 SEC to the center of the voltage range at E0 within which either 1,000,000 or 99,999 appears.

REGULATED 120 VOLT SUPPLY

Measure the supply voltage at the test point labeled "+120V" with an accurate voltmeter. Adjust +120 V ADJUST, located on the top side of the counter chassis, for a reading of 120 volts.

TIME PULSE TRIGGER

The Time Pulse Trigger (V601) is a Schmitt trigger circuit. The TIME TRIGGER LEVEL control varies the instantaneous voltage at which an input signal triggers the circuit from one state to another. Whenever the tube is replaced adjust the control until, with no input signal, the potential on the input grid (Pin 2) is -1 volts with respect to the cathode (pin 7). Check TEST operation under two conditions: (1) line power reduced to 105 volts and TIME switch at 1 second (2) normal line voltage and TIME switch at 10^{-6} seconds. An incorrect adjustment will cause either a reading of 100,000 rather than 1,000,000 at the 1 second position or no reading instead of "1" on the 10^{-6} seconds position. If necessary, re-adjust the control until correct readings are obtained under both conditions.

ATTENUATOR ADJUSTMENTS

Two ceramic trimmer capacitors on each attenuator assembly must be adjusted properly to prevent the attenuator from distorting the input signal. When the counter chassis is upside down and the attenuator shafts are pointing at the viewer, the capacitor on the right side of each attenuator is C303 and that on the left C302. To adjust, apply a 500 cps square wave signal at one of the counter INPUT jacks. Observe the corresponding amplifier output at Pin 1 of V302 with a 100 KC band-width oscilloscope. Turn the attenuator to 10 on the AC side. Adjust the input signal to about 1 volt peak-to-peak. Adjust the TRIGGER VOLTAGE control to any position in which the channel triggers. Adjust C303 for a square wave output. Then, turn the attenuation control to 100 on the AC side and adjust the input signal to about 10 volts peak-to-peak. Adjust C302 for a square wave output.

OTHER ADJUSTMENTS

Note: The following adjustments become necessary only after long use or when circuit components other than tubes are replaced.

Heterodyne Output Filter (L708, L709, L710) This is a low pass filter with a cutoff about 1.2 MC. It is adjusted by three slugs located on the under side of the heterodyne chassis. To expose them remove the shield covering the bottom of the chassis. The three slugs are arranged in a row near XV704. Couple a 1.1 MC signal to grid 1 of the mixer (pin 1, V704). Turn the FREQUENCY SELECTOR to "0". Rotate all the slugs fully counterclockwise. Observe the signal at the heterodyne OUTPUT jack with an r-f voltmeter. Adjust the level of the 1 MC signal to yield about 200 millivolts at the OUTPUT jack. Turn each slug an equal distance clockwise until the output is reduced 10%.

1 MC Trap (L707, C718). This filter removes the 1 MC fundamental from the output of the frequency selector. It is adjusted by a slug tuned coil located on the top of the heterodyne chassis near V704. Turn the FREQUENCY SELECTOR to "0". Inject a 1 MC signal at the junction of L704, R716 and C720. Observe the signal at the plate of the mixer (pin 7, V704) using a voltmeter with a diode probe. Adjust the slug for a minimum reading.

1 MC Amplifier Plate Coil (L701). This coil tunes the first stage of the harmonic generator to 1 MC. The tuning slug is located on the under side of the heterodyne chassis near XV701. Hold a voltmeter diode probe near the plate lead (pin 5, V701) and adjust the slug for a maximum reading on the meter.

Turret Switch Capacitors. These capacitors are located on the circumference of the large plastic disk connected to the FREQUENCY SELECTOR knob. As the knob is rotated each is coupled successively to L703 to form a tank circuit tuned to the reference frequency selected. Each capacitor is tuned by adjusting a trimmer capacitor control located on the top of the disk near a number indicating the proper resonant frequency in megacycles. To tune a particular tank circuit turn the FREQUENCY SELECTOR to the reference frequency the circuit should produce. Inject a 90 mv signal 100 KC above this frequency at the Heterodyne INPUT jack. Turn the LEVEL ADJUST fully clockwise. Connect an oscilloscope to the Heterodyne OUTPUT jack. Adjust the trimmer control labelled with the selected reference frequency until the oscilloscope indicates a maximum 100 KC signal. The tank circuit will produce no frequency that is not a harmonic of 1 MC. When the tank is detuned the output simply decreases in amplitude until the adjacent harmonic is reached.

Pickup Loop (L704). This is a single-turn loop which couples the reference frequency at L703 to the mixer. Both coils are located on the top side of the heterodyne chassis above V703. To position the loop properly, introduce a 3.1 MC, 90 mv signal at the Heterodyne INPUT. Turn the LEVEL ADJUST fully clockwise and turn the FREQUENCY SELECTOR to 2 MC. (Be sure that the tank circuit producing 2 MC is correctly tuned). Bend the pickup loop nearer to or farther from L704 to a position which causes the LEVEL pointer to rest at the left margin of the green region.

Heterodyne OUTPUT ADJUST. This potentiometer adjusts the amplitude of the heterodyne output signal. Set up the instrument as described under "PERFORMING SPECIFIC OPERATIONS, Frequency Measurements above 2 MC." Choose an input frequency and a reference frequency which will produce a beat frequency near 500KC. Turn the OUTPUT ADJUST control to the extreme counterclockwise position. Note this position of the shaft. Then, turn the shaft slowly clockwise until the instrument begins counting. Note the distance the shaft has been moved clockwise and turn it further clockwise the same distance.

Heterodyne BIAS ADJUST. This, potentiometer, located at the rear of the heterodyne chassis, adjusts the cathode bias on the mixer tube. With normal line voltage, no heterodyne INPUT signal, FREQUENCY SELECTOR at 28MC and OUTPUT ADJust control set for maximum output (extreme clockwise position), measure the 1 MC signal at the OUTPUT jack with a calibrated oscilloscope. As the BIAS ADJUST is rotated from one extreme to the other, the output voltage should fall to a minimum then rise again. Set the BIAS ADJUST for minimum output. Within normal line voltage variations of ±10% the 1MC output should not exceed 50mv peak-to-peak.

TROUBLE-SHOOTING

The following test equipment is necessary to service the instrument effectively:

1. An oscilloscope, sensitivity 1/4 volt, bandwidth 5 MC, preferably direct coupled.
2. A signal generator, frequency range 100 cps to 2MC, output at least 100 mv rms.
3. A vacuum tube voltmeter.

When the instrument fails to perform properly, first make sure that it is being operated correctly. Some common errors in operation are:

1. TRIGGER VOLTAGE control positioned incorrectly.
2. ATTENUATION control set incorrectly.
   (a) Wrong choice of AC or DC coupling.
   (b) Attenuated signal too strong or too weak.
3. SLOPE switches set incorrectly. (see "PERFORMING SPECIFIC OPERATIONS" for correct setting for each operation.)
4. Input signal coupled to wrong jack.
5. FUNCTION switch set at "times ten" position when original start-stop frequency is above 100 KC. For example:
   (a) FUNCTION switch at E/UT x 10 and TIME switch at 10^{-6}.
   (b) FUNCTION switch at A/B x 10 when B frequency is above 100 KC.
6. Wrong TIME switch setting
   (a) Unit of time measurement too large to measure a brief period under PERIOD operation.
   (b) Time interval too short to measure a low frequency under events-per-unit-time operation.
7. Too much noise on input signal.

When it is certain the instrument is functioning improperly, first check the power supply voltages to see that they lie within the limits listed below.

Supply	Limits of average level	Acceptable ripple
Unreg. pos.	+190v ±10%	15v peak-to-peak
Unreg. neg.	-110v ±10%	5v peak-to-peak
Reg. Pos.	+120v to accuracy of adjustment	0.1v peak-to-peak
Reg. Neg.	-55v to -65v	0.5v peak-to-peak

If the supply voltages are adequate, the next step is to trace the failure to one of the major components. This can be done by observing the start, stop and count pulses at Decks C, E & G respectively of the FUNCTION switch. If the signals at these points approximate the proper output waveforms of the pulse sources, the trouble lies in the Gate and Control Circuitry or the indicating DCU's. Refer to the schematic diagram, Figure 13, to determine the source of pulses when the FUNCTION switch is in a particular position. If a deficient pulse is found the trouble lies in that pulse source.

When the trouble has been traced to one of the major components consult the Circuit Description section of this manual and the waveforms of Figure 12 for guidance in locating the specific fault. The Input Trigger Channels may be conveniently checked by observing whether or not a pulse is produced as the TRIGGER VOLTAGE control is rotated from one extreme to the other and back.

Tubes, chokes, germanium diodes and pulse transformers are the most common sources of trouble. A transconductance tube tester will not always detect a faulty tube and, conversely, the tester may reject a tube which is functioning

properly. Although the circuits are designed for wide tube variation, avoid swapping tubes or wholesale replacement. An aged tube is generally more reliable than a new tube, because catastropic failure usually occurs early in the life of a tube if at all. An aged tube undergoes only a gradual loss of transconductance, emission, etc.

PREVENTIVE MAINTENANCE

Since a tube tester will not detect tubes which are likely to cause trouble and it is undesirable to replace tubes wholesale as they grow old, other methods must be used to forestall failures. The most effective method is "marginal checking". In its simplest form this consists in causing intermittent or latent failures to manifest themselves by operating the instrument at exceptionally high or low line voltages. A variable auto-transformer may be used to manipulate the line voltage.

5 Parts list

UPPER CHASSIS (COUNTER UNIT)

This parts list is compiled to assist the customer to replace a component which might become defective. Any part which is not adequately described in the schematic diagrams is included here.

TUBES

Type	Quantity	Type	Quantity
5965	15	6080	1
6U8	4	6350	15
6AL5	2	6AS6	1
6AU6	1	5687	1
		6AH6	1

Detail No.	Stock No.	Description	Mfr. & No.
		RESISTORS	
R106	1-6257	1 M, 1 W, 5 % Deposited Carbon Film	IRC
R113	1-6258	500 K, 1 W, 5 % Deposited Carbon Film	IRC
R247	1-2956	Potentiometer 10 M, W/ Switch	CRL BA026-000
R318	1-5573	Potentiometer 10 K, Tapped at 40% CW Rotation	Allen-Bradley JU 1031 SD 3048
R511	1-6012	560 K, 1 W, 5 % Deposited Carbon Film	IRC
R515	1-4258	50 K, 1 W, 1 % Deposited Carbon	IRC

Detail No.	Stock No.	Description	Mfr. & No.
R642	1-6010	3.9 M, 1 W, 5 % Deposited Carbon	IRC
R645		Same as R642	
R648		Same as R642	
R651		Same as R642	
R654		Same as R642	
R660	1-3846	33K, 1 W, 1% Deposited Carbon	IRC
		CAPACITORS	
C101	2-4254	125 μfd, 350v	Mallory FP140
C104	2-3982	8 μfd, 250v	Sangamo MT 2508
C106	2-5630	125 μfd, 350v, Electrolytic	Sangamo PL 351255
C110		Same as C104	
C202	2-2138	25 μμfd, Mica	Sangamo RR1425
C203	2-2760	.25 μfd, 400v, Paper	Sangamo 3004025
C205		Same as C202	
C207		Same as C202	
C208		Same as C202	
C210		Same as C202	
C211	2-1847	5 μμfd, Mica	Sangamo RR 1550
C214	2-5691	.1 μfd, 400v, Metalized Paper	Hopkins Eng. P140
C215		Same as C214	
C216	2-6122	1 μfd 200v	Sprague 2 TM-M1
C220	2-2136	100μμfd , Mica	Sangamo RR 1310
C221	2-2141	50μμfd, Mica	Sangamo RR 1450
C222		Same as C220	
C302	2-2326	5-25 μμfd, Variable	Erie 557-5
C303		Same as C302	
C304	2-1939	20 μμfd, Mica	Sangamo RR 1420
C305	2-6474	3300 μμfd, Mica	Sangamo CR 1233
C306	2-2608	300 μμfd, Mica	Sangamo RR 1330

Detail No.	Stock No.	Description	Mfr. & No.
C307	2-2607	33 μμfd, Mica	Sangamo RR 1433
C308	2-2608	300 μμfd, Mica	Sangamo RR 1330
C309	2-2082	10 μμfd, Mica	Sangamo RR 1410
C312		Same as C309	
C403			
	2-3620	120 μμfd, Mica	Sangamo 1312
C407	2-2135	15 μμfd, Mica	Sangamo RR 1415
C408	2-3948	.1 μfd	CD Tiny Chief
C409	2-3106	33 μμfd	Erie NPO
C410			
	2-5706	2-18 μμfd, Variable	JFD VC4
C501	2-2082	10 μμfd, Mica	Sangamo RR 1410
C503	2-2138	25 μμfd, Mica	Sangamo RR 1425
C504	2-3879	56 μμfd, 5 %, 500vPPM	Vitramon Type 70
C602	2-2135	15 μμfd, Mica	Sangamo RR 1415
C604	2-2082	10 μμfd, Mica	Sangamo RR 1410
C605	2-2138	25 μμfd, Mica	Sangamo RR 1425
C606	2-3879	56 μμfd, 500 v, 5%	Vitramon Type 70
C607		Same as C604	
C608		Same as C605	
C609	2-3574	470 μμfd, 500 v, 5 %	Vitramon
C610		Same as C604	
C611		Same as C605	
C612	2-4206	.0047 μfd, 5 %	Sprague 186-P-472-53S3
C613		Same as C604	
C614		Same as C605	
C615	2-5603	.047 μfd, 5 %	Sprague 186-P-473-53S3
C616		Same as C604	
C617	2-5604	.47 μfd, 5 %	Sprague 186-P-474-53S3

Detail No.	Stock No.	Description	Mfr. & No.
		OTHER COMPONENTS	
B101	9-3389	Fan Motor	General Industries
CR101	8-5632	Rectifier	Berkeley Division
CR102	8-5633	Rectifier	Berkeley Division
CR201	8-5579	Crystal Diode 9GA2	IRC
CR202, CR203 & CR206			
F101			
	7-5824	Fuse 4 Amp. Slo Blo	Littlefuse 3AG
F102			
	7-5824	Fuse 4 Amp. Slo Blo	Littlefuse 3AG
I101	21-5861	Lamp 24v; .033a -.047a	Western Electric A-1
J202	17-5620	Connector 40 Pin Chassis Mtg.	Cannon DPX-40-34S
L201	3-6164	Choke 500 μ Henry	Wilcor #1500-15
L401			
	3-3511	Choke 190-210 μHenry	Berkeley Division
L402	3-6328	Choke 240 μHenry	Wilco 3240-15
L601		Same as L401	
S201	12-6029	Switch 4 Sec., 11 Position	Berkeley Division
S205	12-2600	Switch DPDT Pushbutton	Switchcraft #FF1006
S301	12-5698	Switch 2 Sec., 7 Pos.	Berkeley Division
S601	12-5700	Switch 7 Pos. 1 Pole	Berkeley Division
T101	6-6333	Power Transformer	Berkeley Division
T301	6-5821	Pulse Transformer Ferrite Core 300 μ H., .25 μ sec. pulse width	Berkeley Division
Y401			
	13-5696	Crystal 1 Mc W/ Oven	Berkeley Division

Detail No.	Stock No.	Description	Mfr. & No.
C907		Same as C309	
C908		Same as C307	
C912		Same as C308	
R906		Same as R 318	
T901	6-S6448	Transformer 100 μ Henry	Pulse Engineering

LOWER CHASSIS (HETERODYNE UNIT)

TUBES

Type	Quantity
6AH6	3
6BE6	1
6U8	1

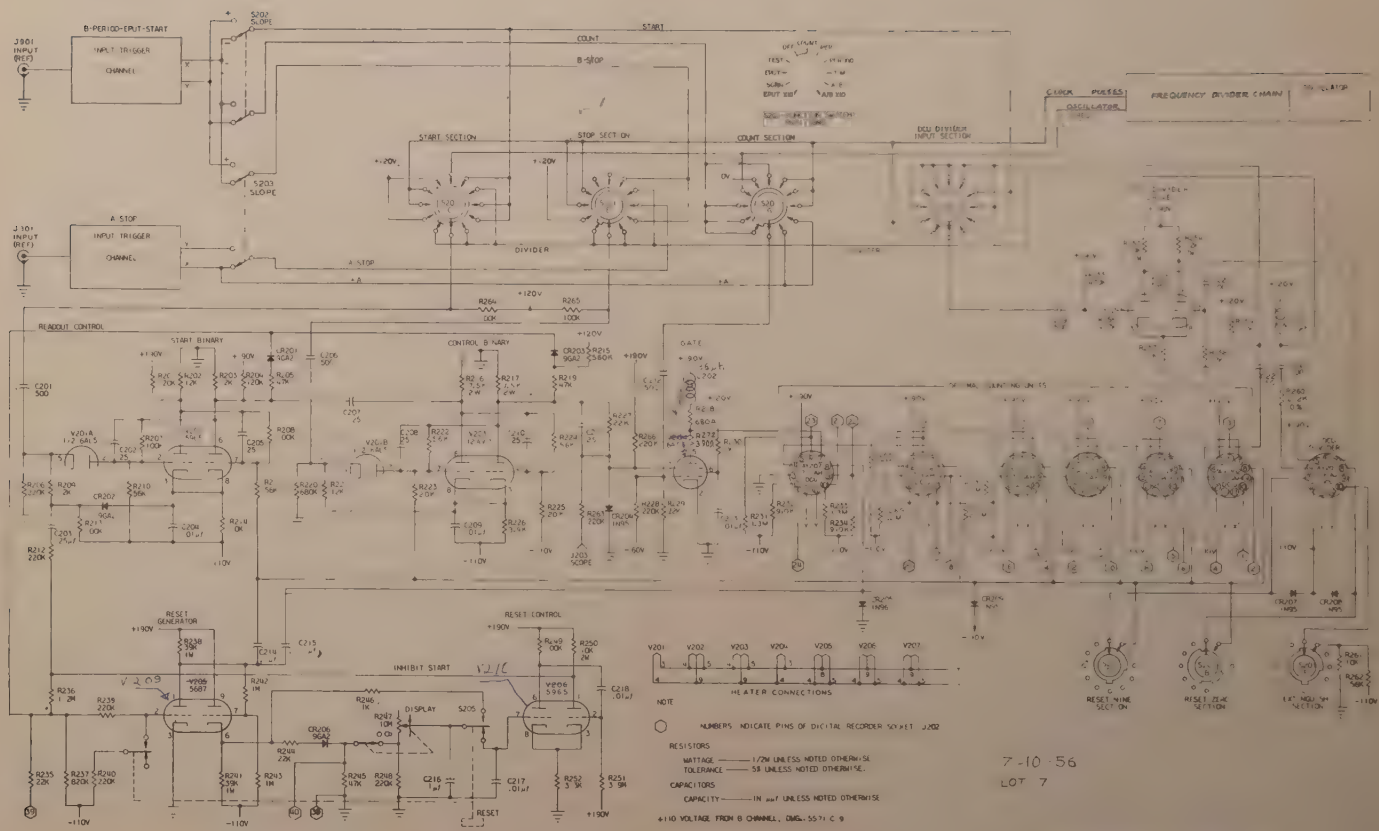
Detail No.	Stock No.	Description	Mfr. & No.
		CAPACITORS	
C701	2-3242	.001 μfd	Erie GPK
C704		Same as C701	
C709		Same as C701	
C712	2-3085	.1 μfd, at 400 V	Sprague 78P10404S5
C713	2-2112	20 μfd, at 450 V	Sangamo PL 4520
C716	2-3065	1000 μμfd, Mica	Sangamo KR 1210
C719	2-3504	500 μμfd	Erie GPK
C720	2-5223	2.2 μμfd	Erie NPOK
C722		Same as C701	
C723	2-3193	10 μμfd, Ceramic	Erie GPK
C724	2-3194	39 μμfd, Ceramic	Erie GPK
C725		Same as C724	
C726		Same as C723	
C727	2-2127	.0015 μfd, Ceramic	GP2L
C728		Same as C727	
C732	2-2760	.25 μfd, Tub.	Sangamo Type 30
C752	2-3217	525/1415 μμfd, Padder	Arco 309
C752A	2-3072	7000 μμfd	Sangamo CR 06270
C753	2-3097	340/1070 μμfd, Padder	Arco 307
C753A	2-3071	3000 μμfd	Sangamo CR 1230
C754	2-3095	180/670 μμfd, Padder	Arco 305
C754A	2-3066	1500 μμfd	Sangamo CR 1215

Detail No.	Stock No.	Description	Mfr. & No.
		CAPACITORS	
C755	2-3096	65/320 μμfd	Arco 303
C755A	2-3065	1000 μμfd, 500 V, 5 %	Sangamo KR 1210
C755B	2-3076	100 μμfd, 10 %, Radial lead	Erie NPO
C756	2-5617	4.5-100.7 μμfd, Air Trimmer	All Star MAPC-100
C756A	2-3064	800 μμfd, 500 V, 5 %	Sangamo KR 1380
C756B	2-3074	50 μμfd	Erie NPO
C757		Same as C756	
C757A	2-3246	600 μμfd	Sangamo KR 1360
C758		Same as C756	
C758A	2-3070	430 μμfd	Sangamo RR 06343
C758B	2-3084	Phenolic Dipped 25 μμfd, Radial Lead	Erie NPO
C759		Same as C756	
C759A	2-2608	300 μμfd, 500 V, 5 %	Sangamo RR1330
C759B		Same as C756B	
C760	2-5613	3.9-76.7 μμfd, Air Trimmer	Hammarlund MAPC-75
C760A		Same as C759A	
C761		Same as C760	
C761A	2-3624	220 μμfd	Sangamo RR 1322
C762		Same as C760	
C762A	2-3068	180 μμfd	Sangamo RR 1318
C763	2-5612	3.2-50.0 μμfd, Air Trimmer	Hammerlund MAPC-50
C763A	2-1943A	150 μμfd	Sangamo RR 1315
C764		Same as C763	
C764A	2-3067	130 μμfd	Sangamo RR 1313
C765		Same as C763	
C765A		Same as C755B	
C766		Same as C763	
C766A		Same as C755B	

Detail No.	Stock No.	Description	Mfr. & No.
		CAPACITORS	
C767	2-5611	2.9-36 μμfd, Air Trimmer	Hammarlund MAPC-35
C767A	2-3075	75 μμfd, Radial Lead Phenolic Dipped	Erie NPO
C767B	2-3081	10 μμfd, Radial Lead Phenolic Dipped	Erie NPO
C768	2-5626	2.6-26.0 μμfd, Air Trimmer	Hammerlund MAPC-25
C768A		Same as C767A	
C769	2-5610	2.3-15.3 μμfd, Air Trimmer	Hammerlund MAPC-15
C769A		Same as C767A	
C770	2-3098	1/10 μμfd	J.F.D. VC11GRA
C770A		Same as C756B	
C770B	2-3083	20 μμfd, Radial Lead, Phenolic Dipped	Erie NPO
C771		Same as C770	
C771A		Same as C756B	
C771B		Same as C767B	
C772		Same as C770	
C772A		Same as C756B	
C772B	2-3080	5 μμfd, Radial Lead, Phenolic Dipped	Erie NPO
C773		Same as C770	
C773A		Same as C756B	
C774		Same as C770	
C774A	2-3106	33 μμfd, Radial Lead, Phenolic Dipped	Erie NPO
C774B		Same as C767B	
C775		Same as C770	
C775A		Same as C774A	
C775B		Same as C772B	
C776		Same as C770	
C776A		Same as C774A	

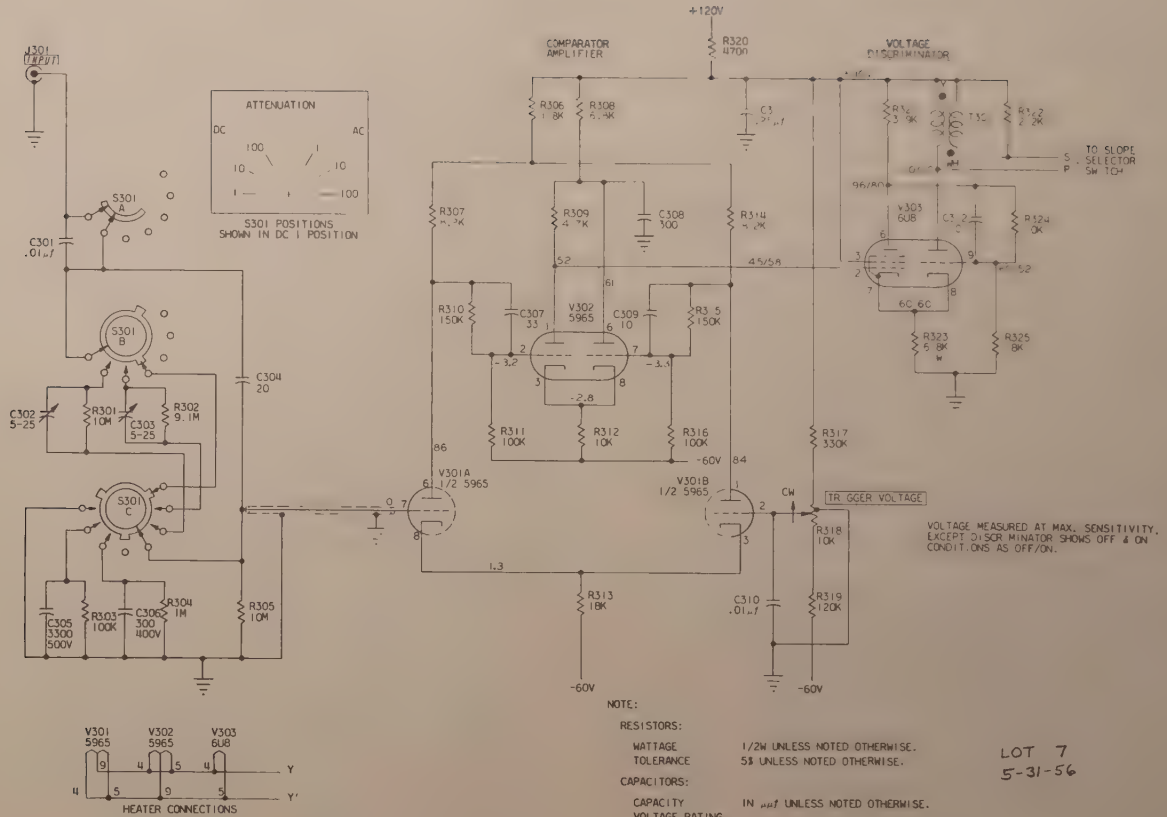
Detail No.	Stock No.	Description	Mfr. & No.
		CAPACITORS	
C776B		Same as C772B	
C777		Same as C770	
C777A		Same as C758B	
C777B		Same as C772B	
C778		Same as C770	
C778A		Same as C758B	
C778B		Same as C772B	
C779		Same as C770	
C779A		Same as C758B	
C780		Same as C770	
C780A		Same as C758B	
C781		Same as C770	
C781A		Same as C770B	
C782		Same as C770	
C782A		Same as C770B	
C783		Same as C770	
C783A	2-3082	15 μμfd, Radial Lead, Phenolic Dipped	Erie NPO
C784		Same as C770	
C784A		Same as C783A	
C785		Same as C770	
C785A		Same as C783A	
C786		Same as C770	
C786A		Same as C767B	
C787		Same as C770	
C787A		Same as C767B	
C788		Same as C770	
C788A		Same as C767B	
C789		Same as C770	
C789A		Same as C772B	
C790		Same as C770	
C790A		Same as C772B	

Detail No.	Stock No.	Description	Mfr. & No.
		CAPACITORS	
C791		Same as C770	
C791A		Same as C772B	
		OTHER COMPONENTS	
L703		Tuning Coil, 5571 A22	Berkeley Division
L707	3-5690	500 μ Henry, Variable	Berkeley Division
L708		Same as L701	
L709		Same as L701	
L710		Same as L701	
CR701	8-2548	Diode, 1N56A	Kemtron
M701	15-5699	Meter, 200 μ Amp	Weston 506, Spec.
L701	3-3198	Choke, 1 Milli Henry, Variable	Scale M601 Berkeley Division



7-10-56
LOT 7

SCHEMATIC DIAGRAM
MODEL 5571
GATE AND CONTROL CIRCUITRY



VOLTAGE MEASURED AT MAX. SENSITIVITY, EXCEPT DISCRIMINATOR SHOWS OFF & ON CONDITIONS AS OFF/ON.

NOTE:

RESISTORS:

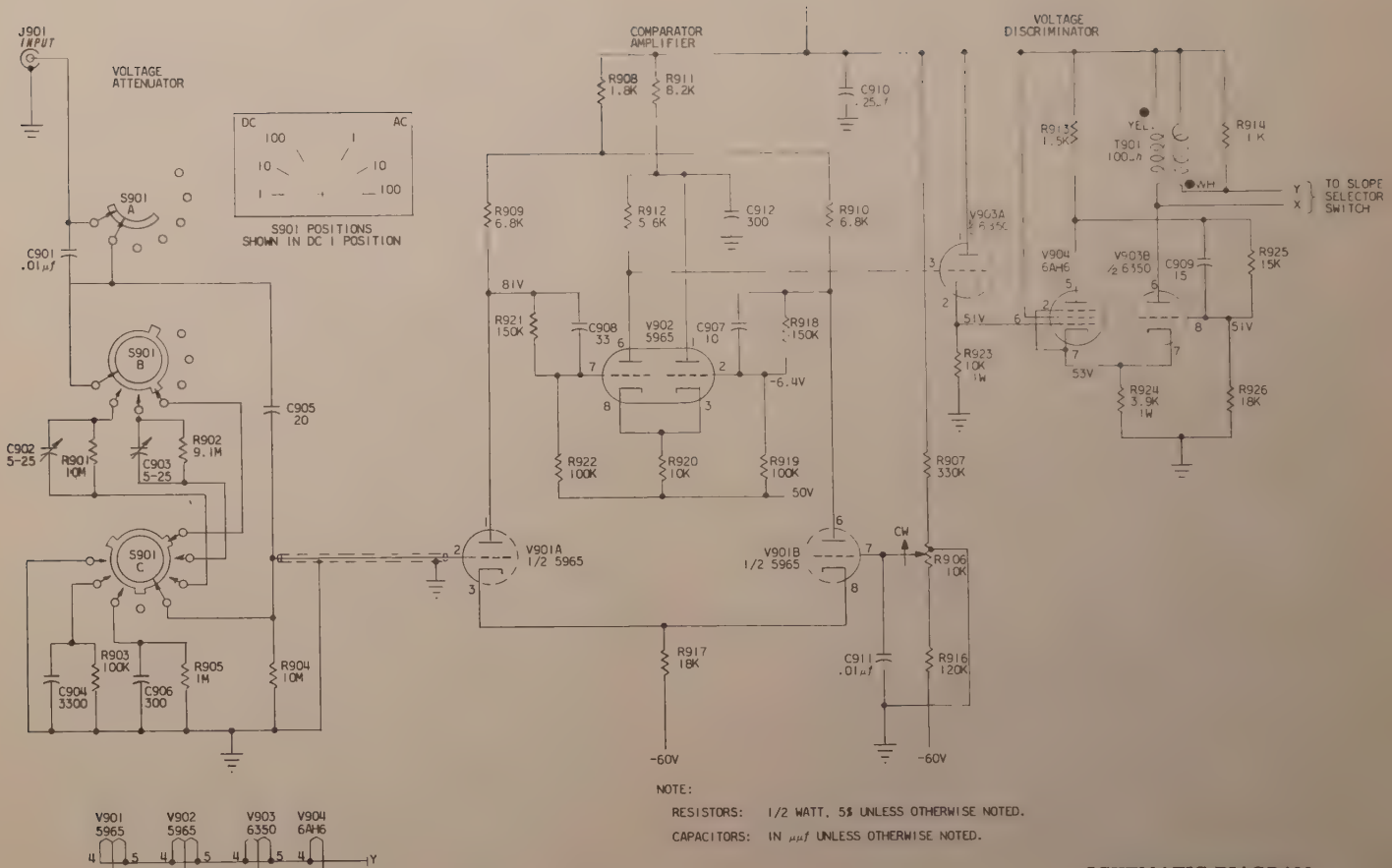
WATTAGE — 1/2W UNLESS NOTED OTHERWISE.
TOLERANCE — 5% UNLESS NOTED OTHERWISE.

CAPACITORS:

CAPACITY — IN μμf UNLESS NOTED OTHERWISE.
VOLTAGE RATING

LOT 7
5-31-56

SCHEMATIC DIAGRAM
MODEL 5571
"A" INPUT CHANNEL



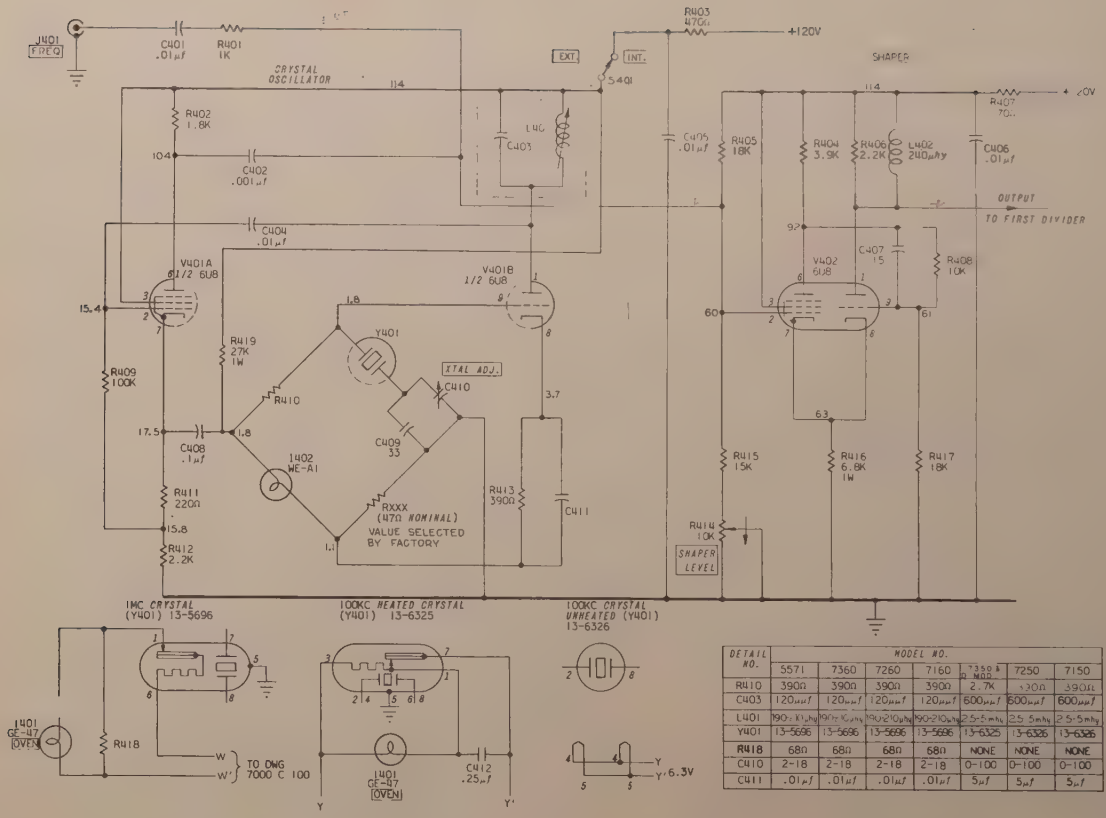
NOTE:

RESISTORS: 1/2 WATT, 5% UNLESS OTHERWISE NOTED.

CAPACITORS: IN μμf UNLESS OTHERWISE NOTED.

LOT 7
5-31-56

SCHEMATIC DIAGRAM
MODEL 5571
"B" INPUT CHANNEL



DETAIL NO.	MODEL NO.						
	5571	7360	7260	7160	7350 & 10 MOD.	7250	7150
R410	390Ω	390Ω	390Ω	390Ω	2.7K	470Ω	390Ω
C403	120μμf	120μμf	120μμf	120μμf	600μμf	600μμf	600μμf
L401	190-210μhy	190-210μhy	190-210μhy	2.5-5 mhy	2.5-5 mhy	2.5-5 mhy	2.5-5 mhy
Y401	13-5696	13-5696	13-5696	13-5696	13-6325	13-6326	13-6326
R418	68Ω	68Ω	68Ω	68Ω	NONE	NONE	NONE
C410	2-18	2-18	2-18	2-18	0-100	0-100	0-100
C411	.01μf	.01μf	.01μf	.01μf	5μf	5μf	5μf

NOTE:

RESISTORS:

WATTAGE 1/2W UNLESS OTHERWISE NOTED.

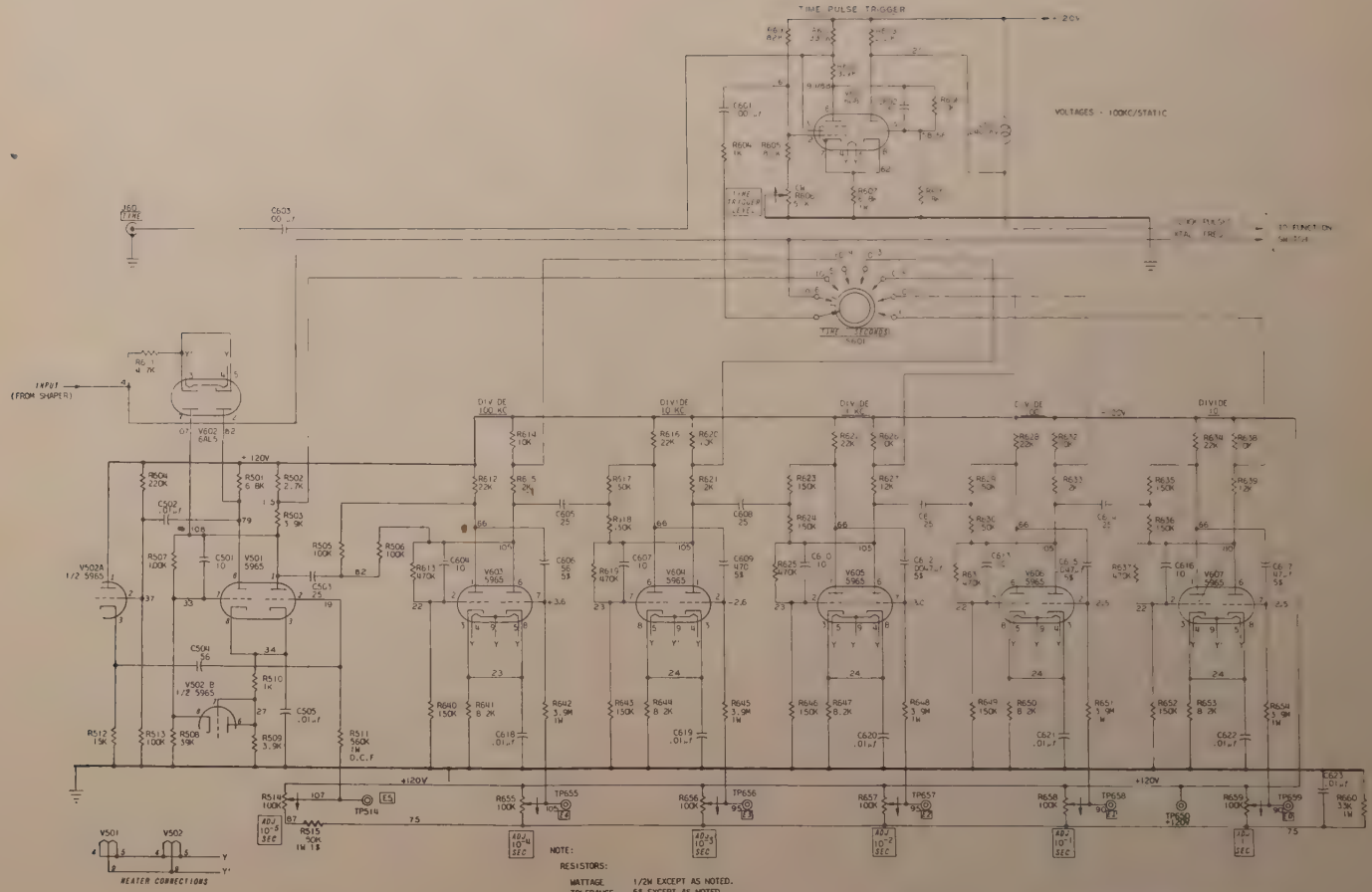
TOLERANCE 5% UNLESS OTHERWISE NOTED.

CAPACITORS:

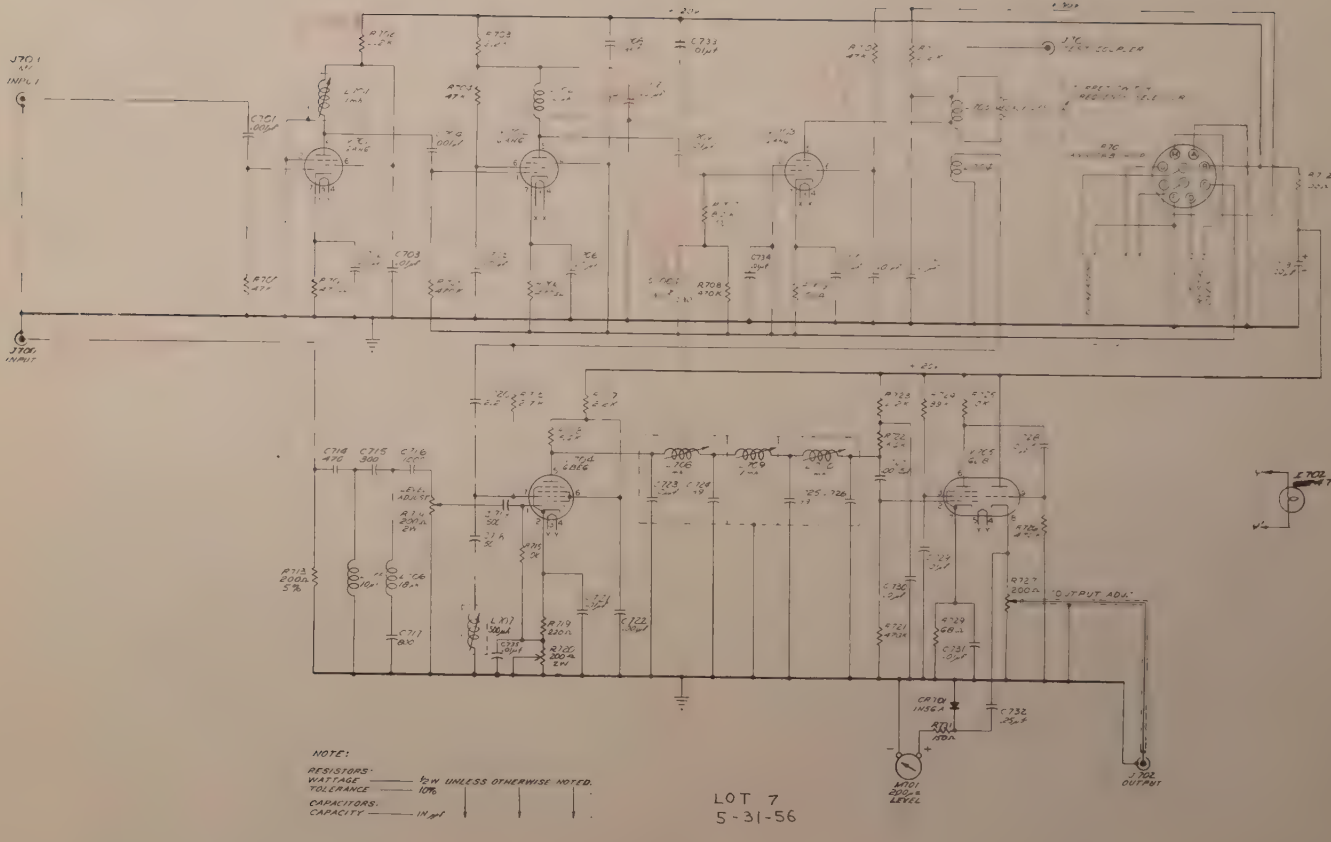
CAPACITY 1M μμf UNLESS OTHERWISE NOTED.

LOT 7
5-31-56

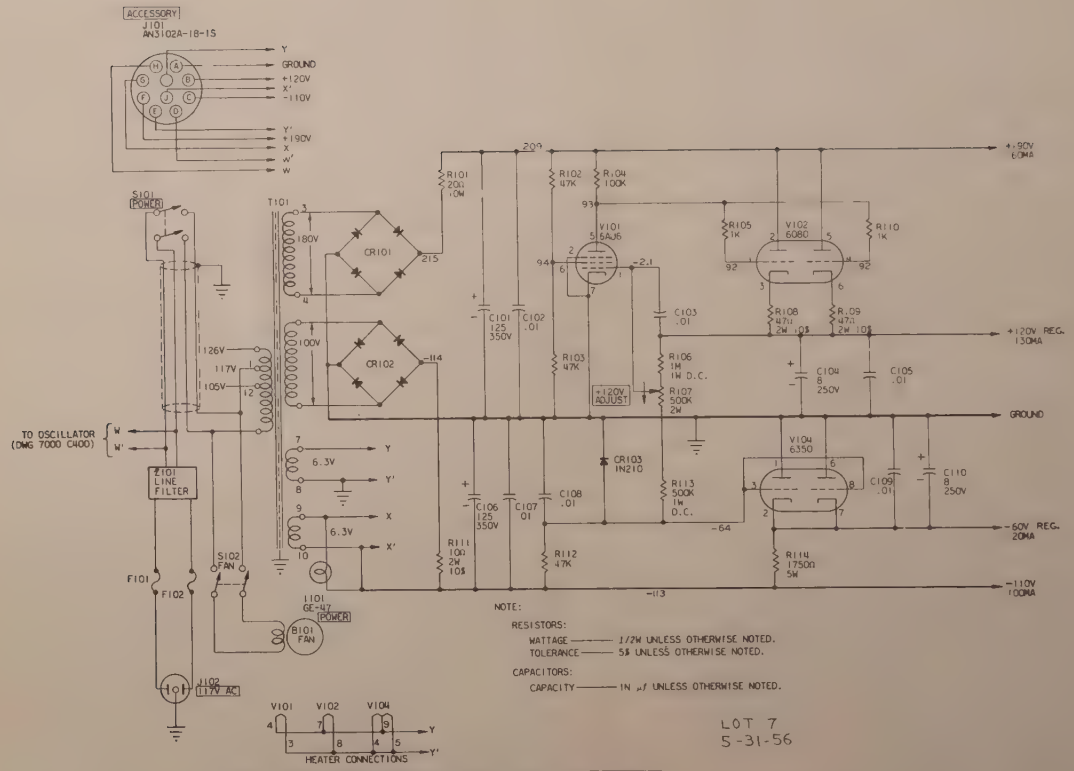
SCHEMATIC DIAGRAM
MODEL 5571
OSCILLATOR AND SHAPER



SCHEMATIC DIAGRAM
MODEL 5571
FREQUENCY DIVIDING CHAIN



SCHEMATIC DIAGRAM
MODEL 5571
HETERODYNE UNIT



NOTE:

RESISTORS:

WATTAGE ——— 1/2W UNLESS OTHERWISE NOTED.

TOLERANCE ——— 5% UNLESS OTHERWISE NOTED.

CAPACITORS:

CAPACITY ——— IN μf UNLESS OTHERWISE NOTED.

LOT 7
5-31-56

	MODEL	5571	7360	7260	7160	7350	7250	7150
DETAIL NO.	F101	4A	4A	4A	4A	3A	3A	3A
	F102	4A	4A	4A	4A	3A	3A	3A
	Z101	SPRAGUE 64B64	NONE	NONE	NONE	NONE	NONE	NONE

SCHEMATIC DIAGRAM
MODEL 5571
POWER SUPPLY

INSTRUCTION MANUAL

Model 711AH
DECIMAL COUNTING UNIT

BERKELEY division of
Beckman Instruments, Inc.

Richmond 4, California
22 March 1956

WARRANTY

Every instrument manufactured by the BERKELEY division of Beckman Instruments, Inc. is warranted to be free from defects in material and workmanship. Our obligation under this warranty is limited to repairing or replacing any instrument or part thereof, except tubes, which shall within one year from date of shipment to the original purchaser prove to be defective after our examination.

Instruments to be repaired must be returned to the factory with transportation charges prepaid. Repair work will be performed only upon receipt of a written purchase order or authorization.

Claims for damage in shipment should be filed promptly with the transportation company. All correspondence concerning the instrument should specify the model and serial number. This information appears on the company name plate.

Experienced service personnel and special test equipment are available at the factory to perform any necessary repairs. Every effort will be made to expedite the repair of instruments returned for servicing.

Any inquiry concerning details of operation, possible modifications, etc., should be addressed to the Sales Department, BERKELEY division of Beckman Instruments, Inc., Richmond 4, California.

INTRODUCTION

The Model 711AH Decimal Counting Unit is direct-reading, plug-in electronic counter. The number of counts received is indicated by the illumination of one of ten neon lamps placed behind a numbered acetate panel. Each unit counts from zero to nine, the tenth pulse resetting the counter to zero and simultaneously generating an output signal. The maximum repetition rate of the input is two million counts per second.

The Model 711AH will drive Models 713AH which counts at 200,000 cycles per second. Model 713AH will drive Model 705AH which counts at 100,000 counts per second. These units may be cascaded to form a counter whose total capacity depends only on the number of DCU's used. Thus, six units will count to 999,999 resetting to 000,000 on the 1,000,000th pulse.

SPECIFICATIONS

Count Indication	Direct reading decimal presentation
Power Requirements	Heater: 6.3V at 1.8A
	Plates: 160 to 250 volts (design center is 190v at 55 ma)
Input Requirements	Negative pulse, 10 volt peak amplitude
Rise Time	Less than 0.12 μsec.
Duration	0.25 μsec.
Output Characteristics	Designed to drive a Model 713AH Decimal Counting Unit
Reset to Zero	Accomplished by Negative pulse to reset bus (pin 8 of the DCU plug)
Maximum Counting Rate	2,100,000 cps
Construction	Plug in unit, 11 pin socket
Dimensions	1 3/4" x 5 1/2" x 5 1/2 "
Weight	1 lb.
Tubes	4 12AV7's

OPERATION

Normally, Decimal Counting Units are installed in Berkeley instruments. No special instructions are necessary. For unusual installations, we invite your inquiry.

Power Requirements:

Plate:	160 to 250 volts (design center is 190V at 55 ma)
Filament:	6.3 volts at 1.8 amps

Input requirements:

A negative pulse of 10 volts peak amplitude is required to trigger the unit. The rise time should be less than 0.12 microseconds, and the duration at least 0.25 microseconds. When the unit is powered by an unregulated supply, the drive amplitude should be proportional to the actual B+ voltage.

Output Characteristics:

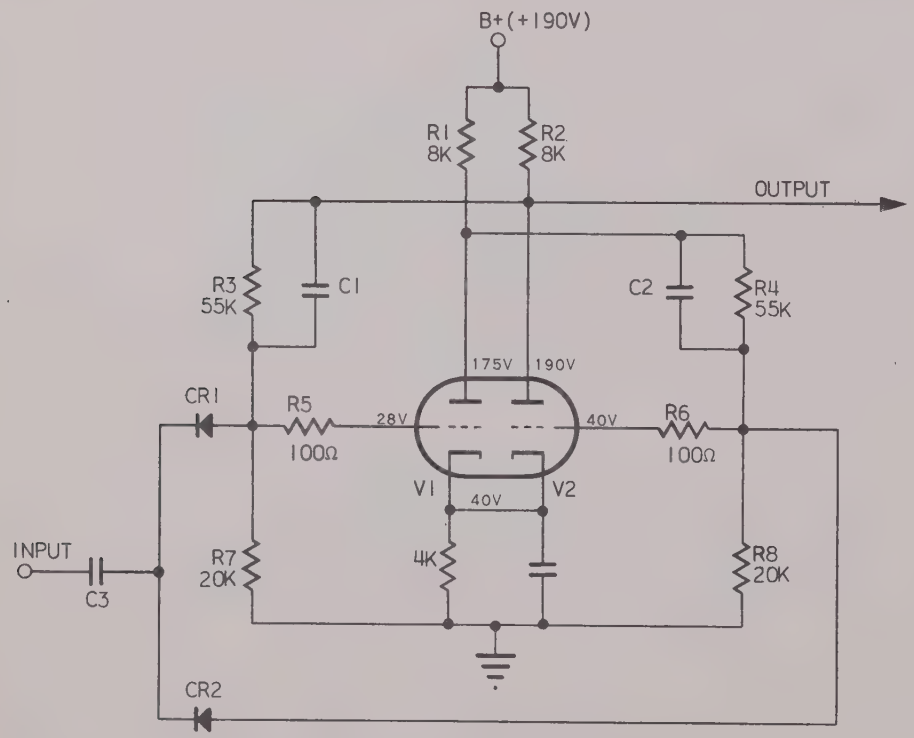
The output is a rectangular waveform as shown in Figure 3. It is represented at the output terminal as a change in direct current voltage level. During count display "0" thru "3" it is 125 volt; during count display "4 thru 9", 175 volts. Ordinarily, the 50-volt negative transient produced at the count of ten drives the following decimal counting unit. The load imposed on a unit must not be more than a 27,000 ohm resistor in series with a 39 $\mu\mu$f capacitor to ground.

Regardless of the number of units, all may be set back to zero by applying a negative pulse to a common line connected to pin 3 of the 11-pin socket. Care must be taken to avoid coupling voltage surges into the input or power supply circuits.

THE BINARIES

The Model 711AH contains four "flip-flop" circuits. These circuits are modifications of the well-known Eccles-Jordan trigger circuit. They are referred to here as binaries.

Figure 1 shows a typical binary. It consists of two triode voltage amplifiers with the plate of each direct-coupled to the grid of the other. With no input this circuit assumes one of two stable states: V1 conducting steadily and V2 cut off, or V2 conducting and V1 cut off. Suppose V1 is not conducting. Then, its plate is near the B+ voltage. A portion of this voltage, applied to the grid of V2 through the voltage dividing network R4 and R8, raises this grid above cut-off and permits V2 to conduct. While V2 is conducting, the low positive potential at its plate, coupled to the grid of V1 through the dividing



VOLTAGES SHOWN ON DIAGRAM ARE THOSE EXISTING WHEN THE BINARY IS IN A STABLE STATE WITH THE RIGHT TRIODE CONDUCTING.

Figure 1 A Typical Binary (711AH)

network R3 and R7, holds this grid several volts below cut-off. Since small changes in the potential at the grid of V1 will not raise it above cut-off, this state is stable and will persist until disturbed by an appreciable input signal. Notice that, since the circuit is symetrical, the opposite state is equally stable. The circuit is triggered from one state to another by negative transients applied at the input. The input diodes form a gating system which couples the pulse formed at C3 to the grid of the conducting triode but blocks it from the grid of the other triode. Suppose, as before, that V1 is cut off and V2 is conducting. The diode side of C3 will carry a potential of about 40 volts (the same as that on the grid of V2). An applied transient will cause this potential to drop momentarily toward 30 volts. CR1 will not conduct since its plate is negative of 30 volts. However CR2 will conduct and the negative transient at the grid of V2 will lower tube current and cause an amplified rise in plate voltage. This rise will carry the grid of V1 above cut-off. The moment V1 conducts, the drop in voltage at its plate, coupled to the opposite grid, re-enforces the negative transient there. This regenerative action proceeds rapidly until V2 is cut-off and V1 is conducting at a steady rate. The next adequate input transient causes a reverse action and returns the binary to its original state. Thus, the binary completes a cycle for every two input transients applied, making it a scale of two. The output is the drop in voltage at one of the plates as that triode begins to conduct. This output, consisting of one negative transient for every two input transients, is suitable for driving another binary. By connecting binaries in cascade (output of one to input of the next), a counter having a scale of any power of two can be built.

THE SCALE OF TEN

In the Model 711AH three binaries are connected in cascade to form a scale of eight. A fourth binary is arranged to block the input to the second binary during two input pulses to the counter, so that ten rather than eight pulses are required to produce a complete cycle. Figure 2 is a block diagram of the circuit.

At the beginning of a cycle the gate control binary is in the state which holds the gate open. For the first three counts (that is, negative input transients) the unit operates like a simple binary counter. The output of the first binary is connected to only one grid of the gate control binary, the grid which is below cut-off when the gate is open, so that binary is not affected. At count 4 the third binary is triggered for the first time and, in turn, triggers the gate control binary to its other state, closing the gate. The gate is closed during counts 5 and 6. At count 6 the first binary produces an output pulse which triggers the gate control binary back to the "open" state. During counts 7, 8, 9 and 10 the unit again operates like a simple binary chain. At count 10 the third binary produces a negative output transient which will drive another decimal counting unit.

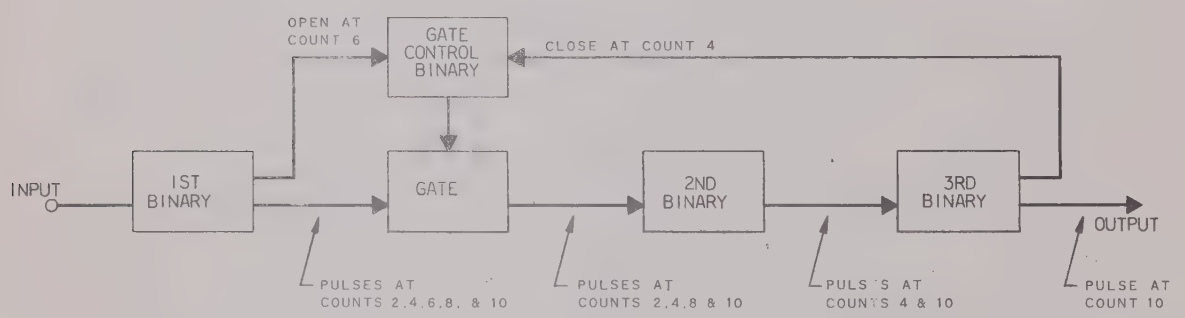


FIGURE 2 BLOCK DIAGRAM

Figure 3 shows how voltages throughout the unit change as successive counts are received. In the case of the cascaded binaries (first, second & third) voltages shown are those at the right-hand plate of each as it appears on the schematic diagram. The output voltage used to drive succeeding binaries is taken from the junction of two plate load resistors in the right-hand triode circuit rather than from the plate itself. These outputs vary positive and negative along with the plate voltages shown in

Figure 3 but the voltage swing is not so great. The negative transients (shown in heavy lines in Figure 3) drive succeeding binaries. One negative transient from the first binary (that which occurs at count 6) does not reach the second binary due to the action described in the paragraph below.

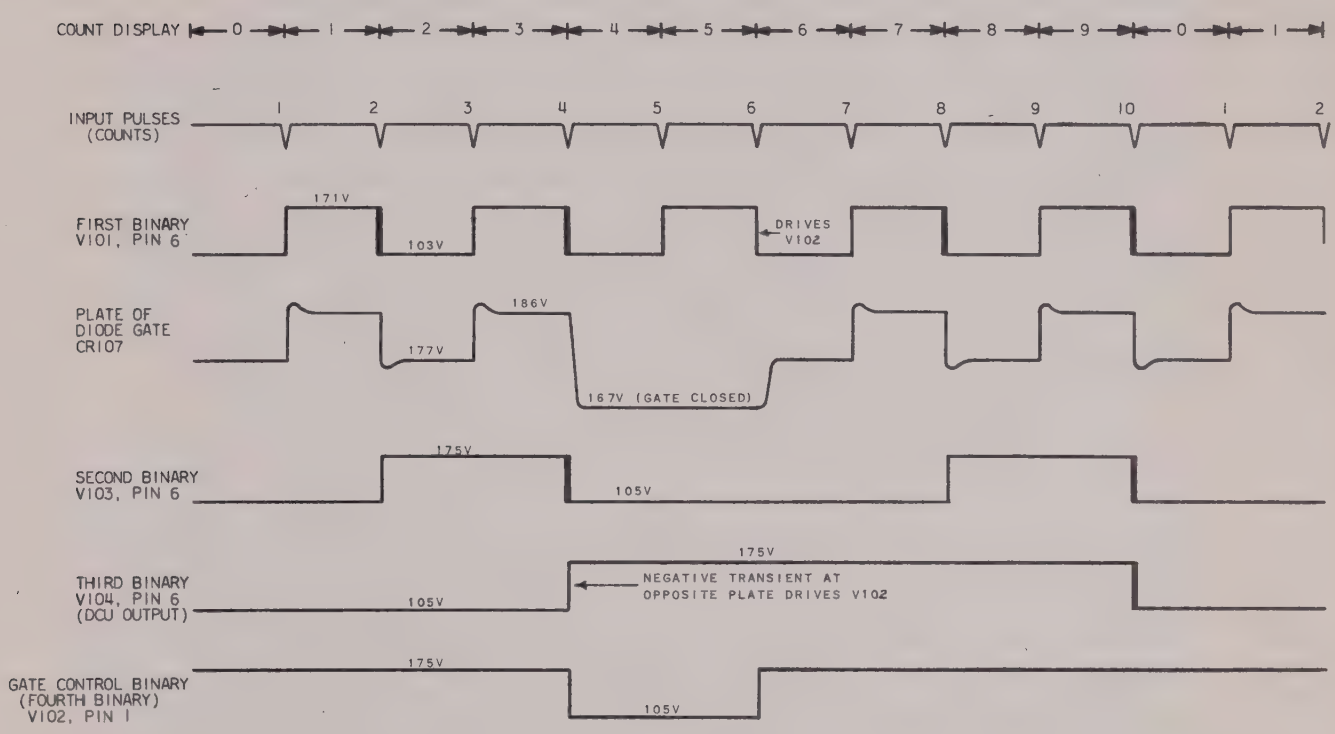


Figure 3 Idealized Waveforms

At count 4, the voltage at the right plate of the third binary rises. This is accompanied by a simultaneous drop in voltage at the left plate. The negative transient produced at the left plate is coupled to the right grid of the gate control (4th) binary, causing it to switch to the state in which the left triode conducts. The resultant voltage drop acorss R131 causes the plate of the diode gate (CR107) to drop to +167v. Since this voltage is negative with respect to the first binary output voltage at the cathode of CR107 (which varies between +186v and +177v), the negative output transient at count 6 cannot reach the second binary. However, the negative

transient produced simultaneously at the junction of T101 and R113 is coupled to the left grid of the control binary which is now above cut-off. This switches the control binary back to its original stable state, opening the gate to pass a trigger signal to the second binary at count 8.

As the unit cycles from one thru ten, ten discreet combinations of binary states are produced. At each combination enough voltage is developed across one (and only one) of the neon indicators to light it. In addition, the right plate of each cascaded binary and the left plate of the gate control binary is connected through a resistor to a pin on the DCU plug. The readout voltages developed at these pins correspond to the voltages shown in Figure 3. When the DCU is installed in a Berkeley instrument, however, the pins are usually connected through a resistor to the B-supply, so that the voltage at the pins varies from below to above ground and back.

MAINTENANCE

When a Decimal Counting Unit is suspected of counting incorrectly, it should be interchanged with another unit in the instrument or replaced with a spare unit to determine whether the trouble is in the suspected unit or in the associated circuitry. This test should be made very carefully. Since the counting unit is usually the indicating device of a larger instrument, faulty operation is often ascribed to it when the symptoms of external faults are displayed.

TROUBLESHOOTING

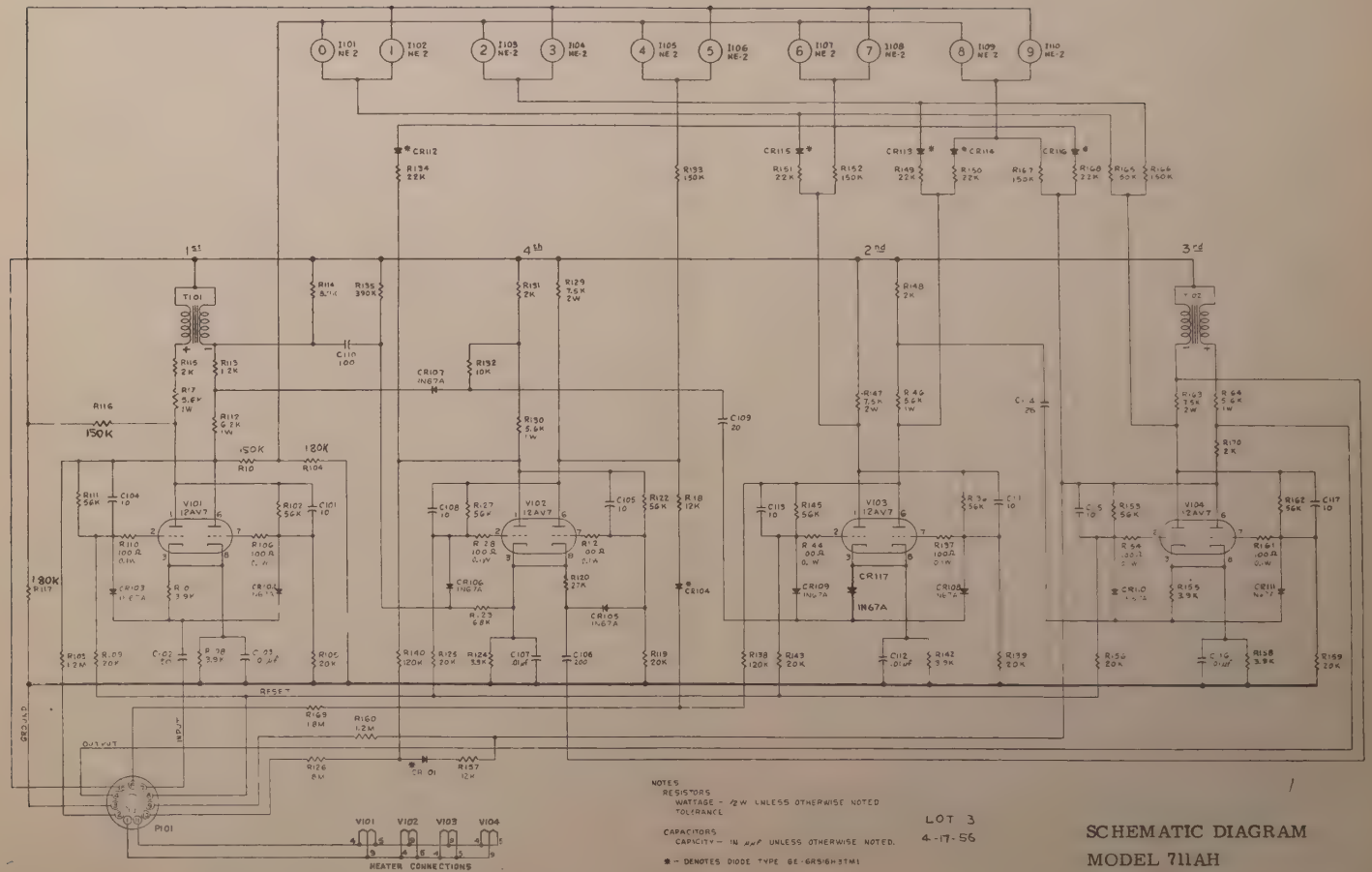
Two methods are recommended for finding the trouble in a faulty counting unit. First, by observing the lighting sequency while driving the unit at a slow repetition rate, and second, by studying the waveform of each stage while driving the unit at a repetition rate fast enough to be conveniently viewed on an oscilloscope. It is impossible to say which method should be used in every case, since marginal failures may occur at high counting speeds and not at lower counting rates, and vice versa. The first method is the only way that a neon lamp failure can be located, and it can be used to locate component and tube failures. For this reason, it is recommended that this method be used first. Table 1 lists common troubles. Faulty tubes cause most failures.

Table 1

COMMON TROUBLES*

Symptom	Cause
Unit fails to count	(a) Insufficient supply voltage (b) Input signal of insufficient amplitude (c) Input signal of wrong polarity (d) First stage inoperative
Unit counts spuriously	(a) Stray input signal (b) Pulses received through power supply (c) External voltages picked up by output lead
Units counts erratically	(a) Input signal too large or small, incorrect rise time (b) Supply voltage fluctuating too much
Unit fails to reset	(a) Stray counts from reset switch or associated circuitry (b) Defective component
Unit counts in wrong sequence (the pattern of lighting is repeated after a definite number of input pulses. One or more lights may be "ON" simultaneously during a cycle provided that the number of states per cycle remains constant).	
1. Unit skips every other number	(a) First stage defective (b) Input circuit supplies double pulses
2. Two stable states per cycle	(a) 2nd stage not being driven.
3. Four stable states per cycle (0123 or 4589)	(a) 3rd stage not being driven.
4. Skips 4 and 5	(a) 4th stage not being driven by the 3rd.
5. Counts up to 4 and 5, then alternates between them as 012345-45, 45	(a) 4th stage not being driven by the 1st.
6. Skips 5 and 6	(a) 4th stage being driven by 1st on 5th input pulse.

* Reset unit before troubleshooting



NOTES
RESISTORS
WATTAGE - 1/2 W UNLESS OTHERWISE NOTED
TOLERANCE

CAPACITORS
CAPACITY - IN μμF UNLESS OTHERWISE NOTED.

* - DENOTES DIODE TYPE GE-1GR516H3TM1

LOT 3
4-17-56

SCHEMATIC DIAGRAM
MODEL 711AH
DECIMAL COUNTING UNIT

INSTRUCTION MANUAL

Model 713AH
DECIMAL COUNTING UNIT

BERKELEY division of
Beckman Instruments, Inc.

Richmond 4, California
22 March 1956

Section 1
INTRODUCTION

The Model 713AH Decimal Counting Unit is direct-reading, plug-in electronic counter. The number of counts received is indicated by the illumination of one of ten neon lamps placed behind a numbered acetate panel. Each unit counts from zero to nine, the tenth pulse resetting the counter to zero and simultaneously generating an output signal. The maximum repetition rate of the input is 200,000 counts per second.

The Model 713AH will drive Model 705AH which counts at 100,000 cycles per second. These units may be cascaded to form a counter whose total capacity depends only on the number of DCU's used. Thus, six units will count 999,999, resetting to 000,000 on the 1,000,000th pulse.

Specifications

Count Indication	Direct reading decimal presentation
Power Requirements	Heater: 6.3V at 1.8A
	Plates: 150 to 230 V (design center is 190V at 20 ma)
Input Requirement Recommended	Negative pulse 50 volt peak amplitude
Rise Time	Less than 0.5 μsec.
Duration	1.0 μsec.
Output Characteristics	Designed to drive a Model 705AH Decimal Counting Unit.
Reset to Zero	Accomplished by Negative Pulse to reset bus (pin 8 of the DCU plug)
Maximum Counting Rate	200,000 cps
Construction	Plug-in unit, 11-pin socket
Dimensions	1 3/4" x 5 1/2" x 5 1/2"
Weight	1 lb.
Tubes	4 12AV7's

Section 2

OPERATION

Installation

Normally, Decimal Counting Units are installed in Berkeley instruments. No special instructions are necessary. For unusual installations, we invite your inquiry.

Operation

Plate	150 to 230 volts (design center is 190V at 20 ma)
Filament	6.3 volts at 1.8 amps

Input requirements:

A negative transient of 50 volts peak amplitude is required to trigger the unit. The rise time should be less than 0.5 μseconds, and the duration at least 1.0 μseconds. When the unit is powered by an unregulated supply, the drive amplitude should be proportional to the supply.

Output characteristics:

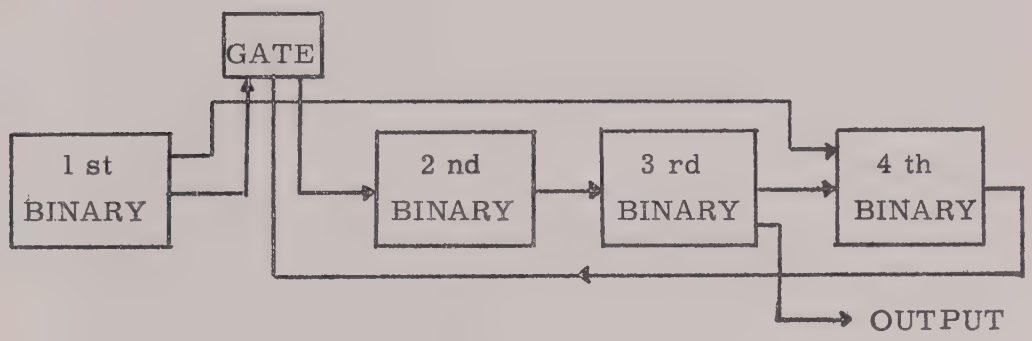
The output is a rectangular waveform as shown in Figure 2. It is represented at the output terminal as a change in direct current voltage level. During count display "0" thru "3" it is 60 volts; during count display "4" thru "9", 130 volts. Ordinarily, the 50-volt negative transient produced at count ten drives the following decimal counting unit. The load imposed on a unit must not be more than a 10,000 Ω resistor in series with a 100 $\mu\mu$fd capacitor to ground.

Regardless of the number of units, all may be set back to zero by applying a negative pulse to a common line connected to pin 3 of the 11 pin socket. Care must be taken to avoid coupling voltage surges into the input or power supply circuits.

Section 3

THEORY OF OPERATION

The basic circuit of the Model 713AH is a modified Eccles-Jordan Trigger Circuit having two stable states. This circuit is referred to here as a "binary". See the Model 711AH manual for the basic theory of the binary. The binary circuit used in the Model 713AH is basically the same as that in the Model 711AH except for the method of triggering:



FUNCTIONAL DIAGRAM MODEL 713AH

Figure 1

In the Model 713AH, four binaries or flip-flops are connected in cascade making a scale of 16. It is permuted to a scale of 10 by a diode gating system. On the count of 0 (zero) the unit is reset to the equivalent of binary 4. It counts as a binary counter until the count of 4 at which time the 4th stage is triggered for the first time. This closes the gate to the second stage preventing it from being driven until the 4th stage is triggered back to its original state, by the first stage, on the count of 6. From this count until the count of 0 (zero) the unit again counts as a binary counter. Gating off the second stage for 2 counts and driving the fourth from the first has the effect of adding six counts internally making the unit a scale of 10.

Section 4

MAINTENANCE

When a Decimal Counting Unit is suspected of counting incorrectly, it should be interchanged with another unit in the instrument or replaced with a spare unit to determine whether the trouble is in the suspected unit or in the associated circuitry. This test should be made very carefully. Since the counting unit is usually the indicating device of a larger instrument, faulty operation is often ascribed to it when the symptoms of external faults are displayed.

Troubleshooting

Two methods are recommended for finding the trouble in a faulty counting unit. First, by observing the lighting sequence while driving the unit at a slow repetition rate, and second, by studying the waveform of each stage while driving the unit at a repetition rate fast enough to be conveniently viewed on an oscilloscope. It is impossible to say which method should be used in every case, since marginal failures may occur at high counting speeds and not at lower counting rates, and vice versa. The first method is the only way that a neon lamp failure can be located, and it can be used to locate component and tube failures. For this reason, it is recommended that this method be used first. Table 1 lists common troubles. Faulty tubes cause most failures.

Diagrams and Tables

Figure 2 shows the idealized waveforms of each stage when the DCU is working properly. A study of these and the corresponding ones of a faulty unit will help in locating components and tube failures. Nominal voltages are shown on the waveforms of Figure 2. These may vary considerably as tubes and components age.

Table 1

COMMON TROUBLES*

Symptom	Cause
Unit fails to count	(a) Insufficient supply voltage (b) Input signal of insufficient amplitude (c) Input signal of wrong polarity (d) First stage inoperative
Unit counts spuriously	(a) Stray input signal (b) Pulses received through power supply (c) External voltages picked up by output lead
Unit counts erratically	(a) Input signal too large or small, incorrect rise time (b) Supply voltage fluctuating too much
Unit fails to reset	(a) Stray counts from reset switch or associated circuitry (b) Defective component
Unit counts in wrong sequence (the pattern of lighting is repeated after a definite number of input pulses. One or more lights may be "On" simultaneously during a cycle provided that the number of states per cycle remains constant.)	
1. Unit skips every other number	(a) First stage defective (b) Input circuit supplies double pulses
2. Two stable states per cycle	(a) 2nd stage not being driven.
3. Four stable states per cycle (0123 or 4589)	(a) 3rd stage not being driven.
4. Skips 4 and 5	(a) 4th stage not being driven by the 3rd.
5. Counts up to 4 and 5, then alternates between them as 012345-45, 45	(a) 4th stage not being driven by the 1st.
6. Skips 5 and 6	(a) 4th stage being driven by 1st on 5th input pulse.

* Reset unit before troubleshooting

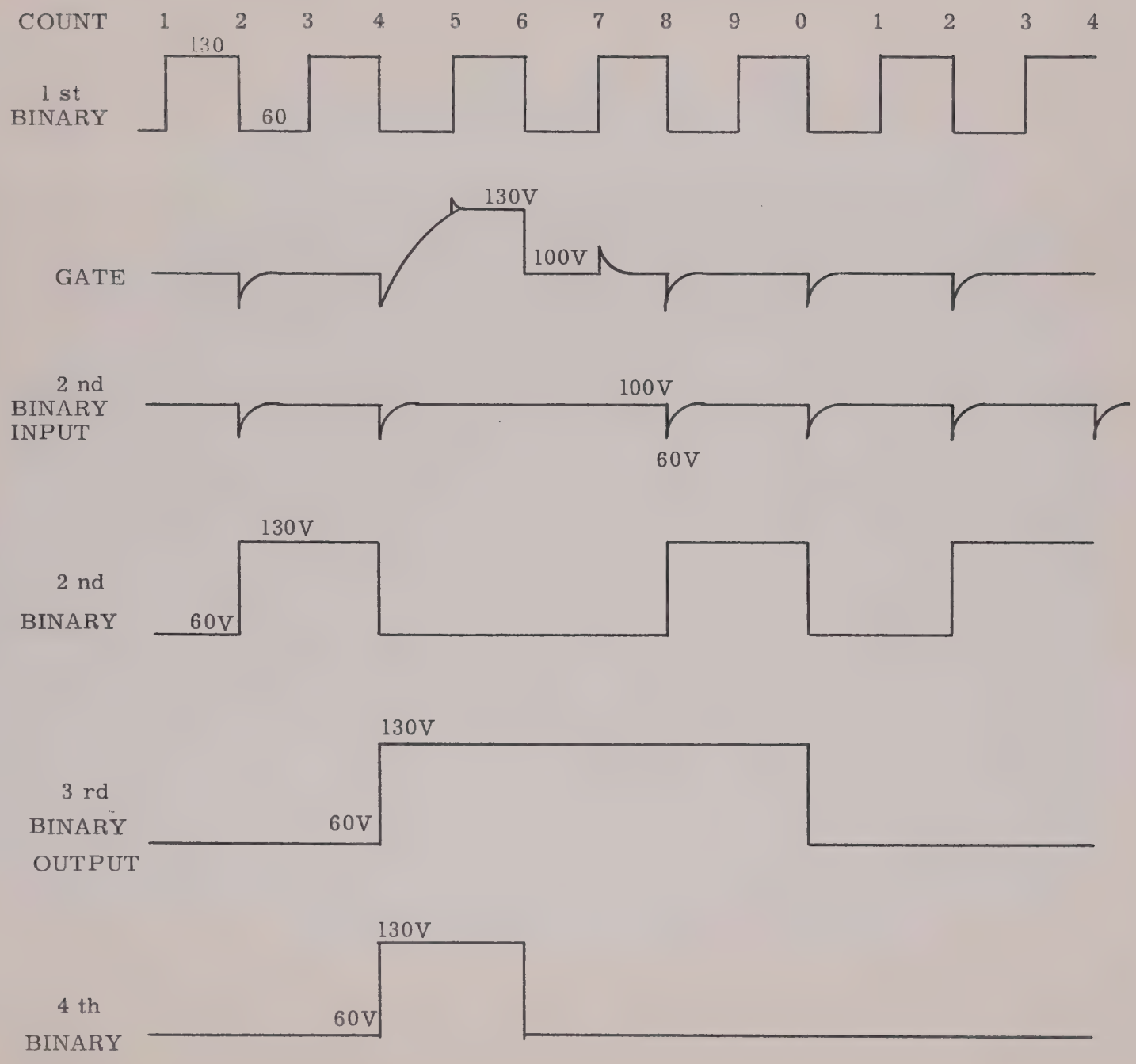
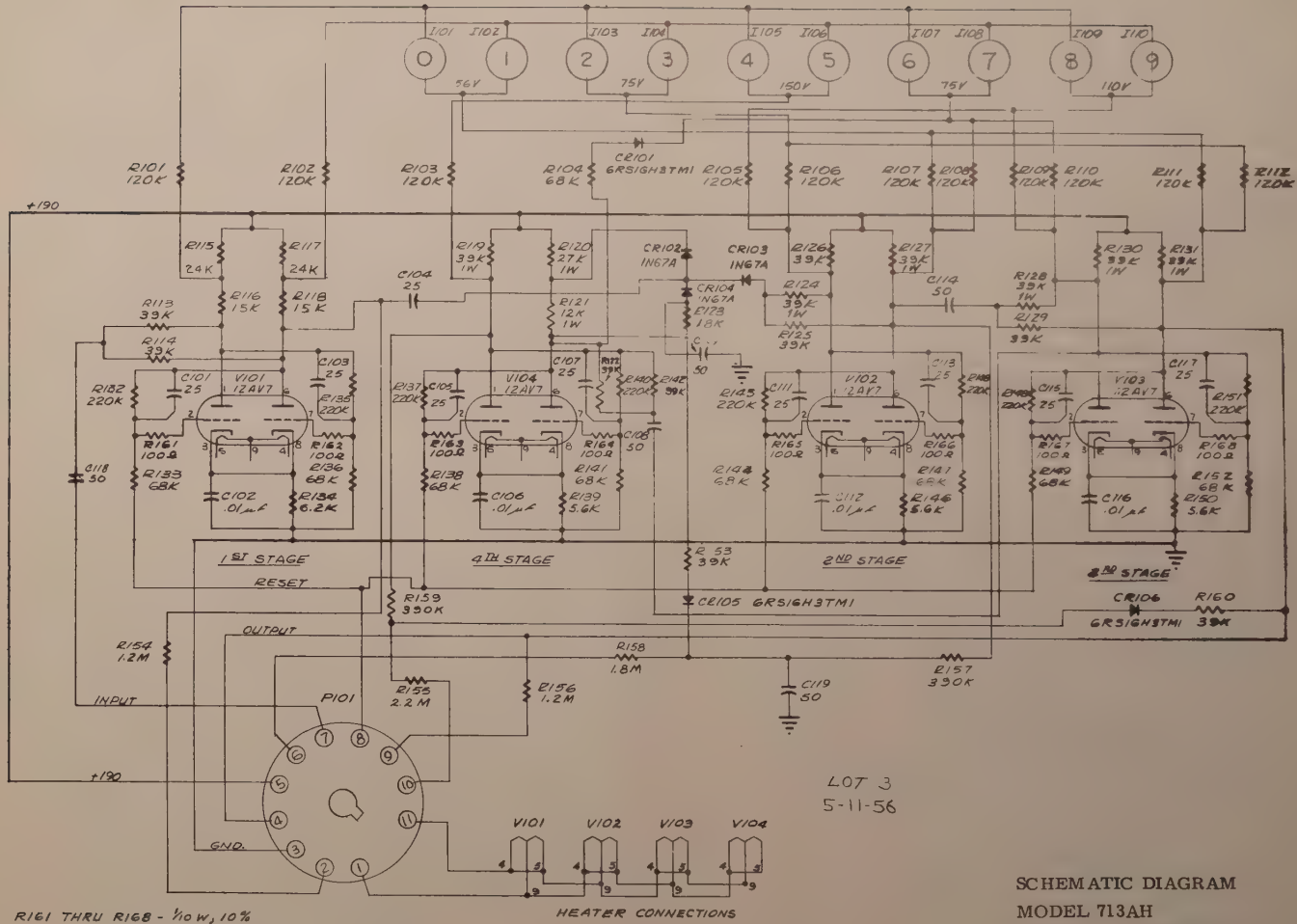


FIGURE 2 PLATE WAVEFORMS - PIN 6



LOT 3
5-11-56

R161 THRU R168 - 1/10 W, 10%
ALL RESISTORS TO BE 1/2 WATT EXCEPT AS NOTED
" " TOL. TO BE ±5% " " "
" CAPACITORS TO BE μμf " "
" " TOL. TO BE ±5% " .01μf

SCHEMATIC DIAGRAM
MODEL 713AH
DECIMAL COUNTING UNIT

INSTRUCTION MANUAL

Model 705AH
DECIMAL COUNTING UNIT

BERKELEY division of
Beckman Instruments, Inc.

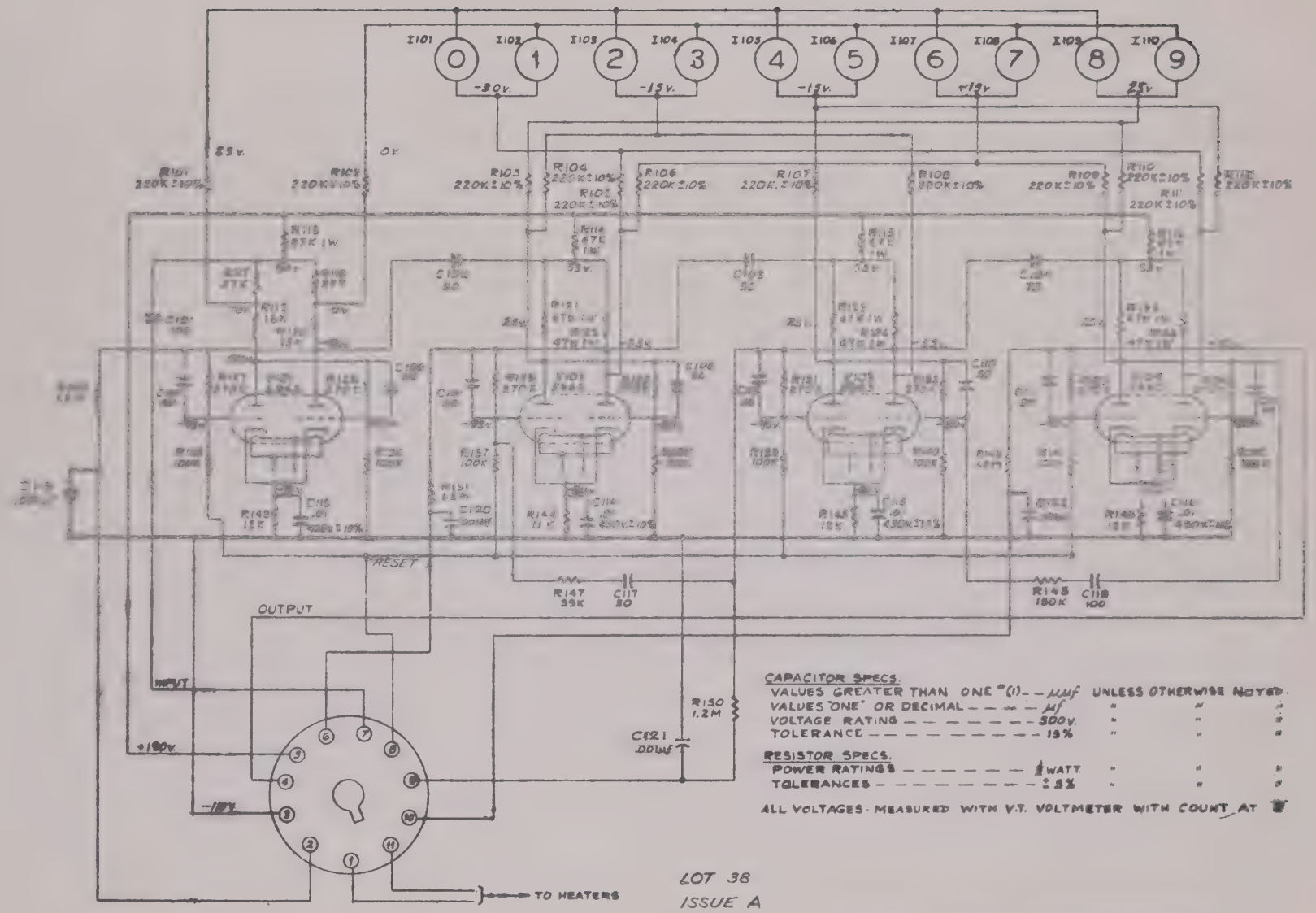
Richmond 4, California
1 April 1955

The Model 705AH is a Model 705AF DCU modified to reset to zero when it receives a negative pulse at pin 8 of the DCU plug. The schematic diagram of the 705AH appears on the next page. The circuitry is identical to that of the 705AF except:

1. All ground connections to the DCU chassis are removed. The unit operates on a +190 volt and a -110 volt B supply.

2. R135, R137, R139 and R141, are connected to pin 8 of the DCU plug. The negative reset pulse reaches the left grid of each binary through these resistors.

3. All cathode resistors and by-pass capacitors and all resistors formerly connected to the reset line are connected to the negative supply at pin 3 of the DCU plug.



CAPACITOR SPECS.

VALUES GREATER THAN ONE "(1)"	$\mu\mu f$	UNLESS OTHERWISE NOTED.	
VALUES "ONE" OR DECIMAL	μf	"	"
VOLTAGE RATING	500v.	"	"
TOLERANCE	10%	"	"

RESISTOR SPECS.

POWER RATINGS	½ WATT	"	"
TOLERANCES	± 5%	"	"

ALL VOLTAGES MEASURED WITH V.T. VOLTMETER WITH COUNT AT

LOT 38
ISSUE A
8-11-55

Schematic Diagram Model 705AH

INSTRUCTION MANUAL

Model 705AJ
DECIMAL COUNTING UNIT

BERKELEY division of
Beckman Instruments, Inc.

Richmond 4, California
1 April 1955

The Model 705AJ is a 705AF DCU modified so that it can be reset to 9 as well as zero and will count without indicating. The schematic diagram of the 705AJ appears on the next page. The circuitry is identical to that of the 705AF except:

1. The readout connections to pins 2, 6, 9 and 10 of the DCU plug have been removed.

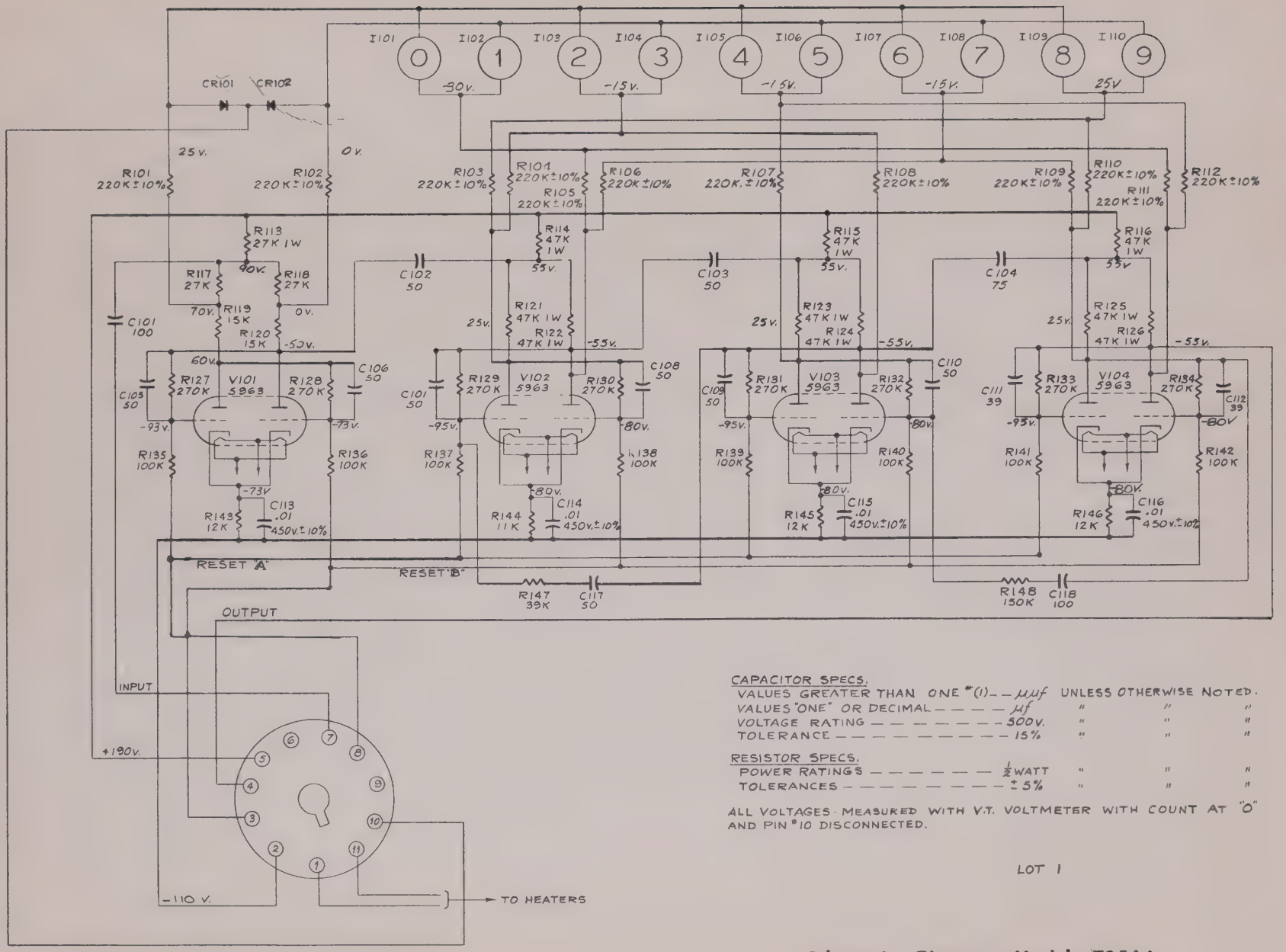
2. All ground connections to the DCU chassis have been removed. The unit operates on a +190 volt and a +110 volt B supply.

3. All cathode resistors and by-pass capacitors are connected to the negative supply at pin 2 of the DCU plug.

4. R135, R137, R139 and R141 are connected to pin 8 of the DCU plug. A negative reset pulse is coupled to the left grid of each binary through these resistors to reset the DCU to zero.

5. R136, R138, R140 and R142 are connected to pin 3 of the DCU plug. A negative reset pulse is coupled to the right grid of each binary through these resistors to reset the DCU to 9.

6. Two selenium diodes (CR101 and CR102) have been connected from one side of the indicating neon bulbs to pin 10 of the DCU plug. When this pin is grounded the voltages developed across the bulbs as the units count are not sufficient to cause them to glow. The unit counts but does not indicate.



CAPACITOR SPECS.

VALUES GREATER THAN ONE	"(1) — μμf	UNLESS OTHERWISE NOTED.	
VALUES "ONE" OR DECIMAL	— — — — μf	"	"
VOLTAGE RATING	— — — — — — — 500v.	"	"
TOLERANCE	— — — — — — — — — 15%	"	"

RESISTOR SPECS.

POWER RATINGS	— — — — — — ½ WATT	"	"
TOLERANCES	— — — — — — — — ± 5%	"	"

ALL VOLTAGES - MEASURED WITH V.T. VOLTMETER WITH COUNT AT "0" AND PIN "10 DISCONNECTED.

LOT 1

Schematic Diagram Model 705AJ

INSTRUCTION MANUAL

Model 705AF
DECIMAL COUNTING UNIT

Lot 6 and above

BERKELEY division of
Beckman Instruments, Inc.

Richmond 4, California
15 December 1953

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Section 2	Operation Installation Operation	2
Section 3	Theory of Operation Basic Design Circuit Analysis	3
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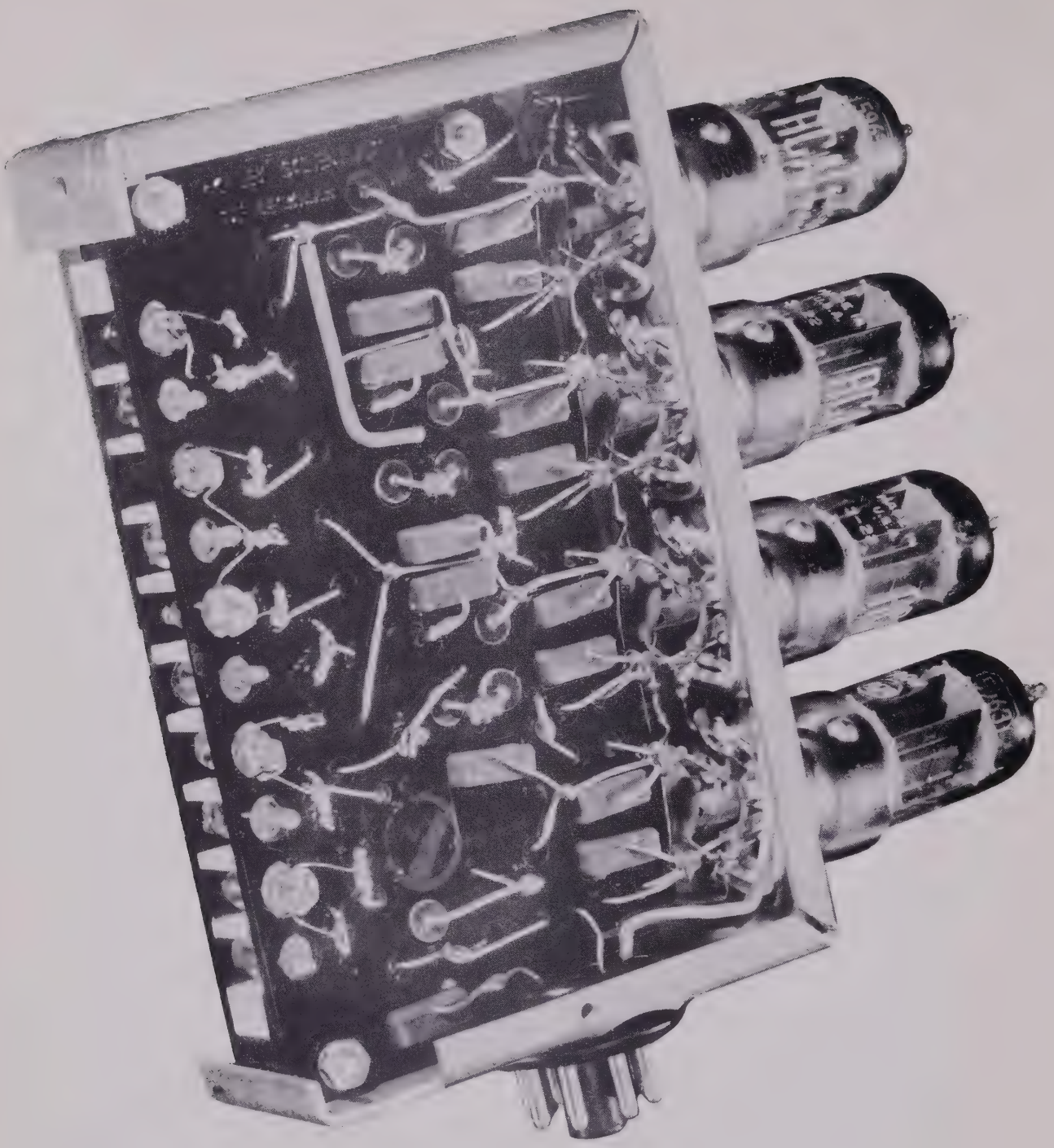


Figure 1 Model 705AF Decimal Counting Unit

Section 1
INTRODUCTION

The Model 705AF Decimal Counting Unit is a direct-reading, plug-in electronic counter with facilities for extracting information from the DCU to operate other electronic devices. The number of counts received is indicated by the illumination of one of ten neon lamps placed behind a numbered acetate panel. Each unit counts from zero to nine, the tenth pulse resetting the counter to zero and simultaneously generating an output signal. any number of these units can be connected in cascade (the output of one unit driving the next), forming a counter whose total count capacity depends only on the number of DCU's. Thus, five units will count to 99, 999 resetting to 00, 000 on the 100, 000th pulse (see Figure 1).

Specifications

Count Indication	Direct reading Decimal presentation
Power Requirements	Heater: 6.3 v. at 1.2 amps. Plates: 300 v. at 15 ma.
Input Requirements, recommended	Negative pulse 100 v. peak amplitude
Rise Time	Less than 1 μsecond
Duration	At least 2 μseconds
Output Characteristics*	Designed to drive Model 705A or 705AF
Resolution of Paired Pulses	5 μseconds
Reset to Zero	Instantaneous through opening of grid
Maximum Counting Rate	100, 000 cps
Construction	Plug-in unit, 11-pin socket

Output information is also presented at four of the pins on the 11-pin plug as high or low voltages, depending upon the number of counts the DCU has received.

Section 2
OPERATION

Installation

Normally, Decimal Counting Units are installed in Berkeley instruments. No special instructions are necessary. For unusual installations, we invite your inquiry.

The reset pin (pin #3 on the 11-pin plug) should be connected to ground through a normally-closed switch or relay contacts. To reset the unit, open the contacts momentarily. Care must be taken to avoid coupling voltage surges into the input or power supply circuits.

Operation

Power requirements:

Plates:	250 volts to 350 volts (nominal 300 volts at 15 ma)
Filaments:	6.3 volts at 1.2 amperes

Input requirements:

If the unit is powered by an unregulated supply, the drive amplitude should vary with the supply voltage. A negative transient is required to drive the unit, either a square wave or a rectangular pulse at least two microseconds wide. The pulse amplitude depends on the rise time. For a rise time of 0.5 microseconds (measured between ten and ninety percent values), the pulse amplitude should be between 75 and 135 volts; for a two microsecond rise time, an amplitude of 120 to 165 volts should be used. Rise times of one microsecond or less, pulse amplitudes of 100 volts and a 300 volt supply offer optimum performance. The input load presented by either unit during triggering is equivalent to 100 $\mu\mu$f in series with 15,000 ohms.

Output requirements:

The output is a rectangular waveform presented at the output terminal as a change in d-c voltage (see Figure 4). Between "0" and "6", the output is 55 volts; "6" and "7", 125 volts; and "8" and "9", 135 volts. The slip between "7" and "8" is caused by an interpolation network.

The load imposed on the unit must not be more than 300K to ground or 6K in series 100 $\mu\mu$f.

Section 3

THEORY OF OPERATION

Basic Design

The basic circuit of the Model 705AF is a modification of the Eccles-Jordan trigger circuit with two stable states, referred to as a binary. It is a two-stage amplifier with the output of the second stage connected to the input of the first, as shown in Figure 2.

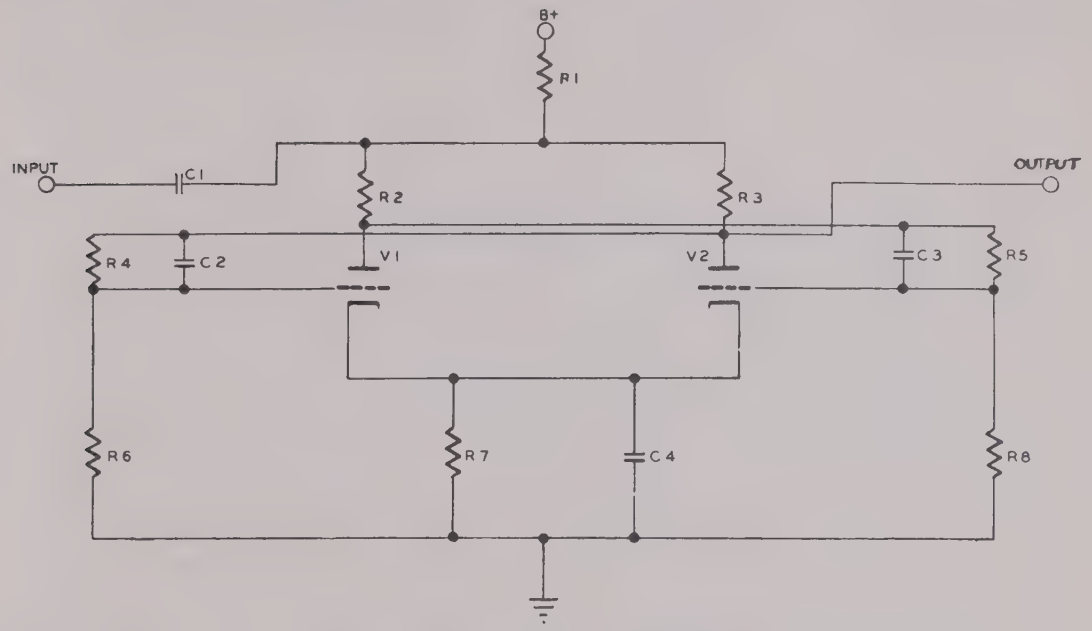


Figure 2, Basic Circuit, Model 705AF

With no input, the loop gain is less than one, and the circuit is in one of its two stable states, i.e., either V2 conducting and V1 cut off, or vice-versa. The circuit is triggered from one state to the other by making the loop gain greater than one. The binary is coupled to a single trigger source through C1 and R1 in such a way that the effect of the trigger is different on the two stages, depending on which stage is conducting. For example, assume that V2 is conducting and V1 is cut off. If a negative pulse is applied to the input, there is a drop in the plate voltage of V1. This drop in voltage is transmitted through a cross-over network (R5, R8, C3 and the grid-to-ground capacitance of V2) and applied to the grid of V2. The plate voltage of V2 then starts to rise, carrying with it the grid of V1. When the input pulse is of sufficient amplitude, the loop gain becomes greater than one, and the binary is triggered to its other stable state, V1 conducting and V2 cut off.

The next input pulse reverses the process and causes the binary to return to its original state. Thus, the binary completes a cycle for every two input triggers and is a scale of 2. By a cascade arrangement of binaries, a counter having a scale of any power of 2 can be obtained.

Circuit Analysis

Four binaries are connected in cascade forming a scale-of-16 which is permuted to a scale-of-10 by two resistor-capacitor "feedback" networks (see Figure 3).

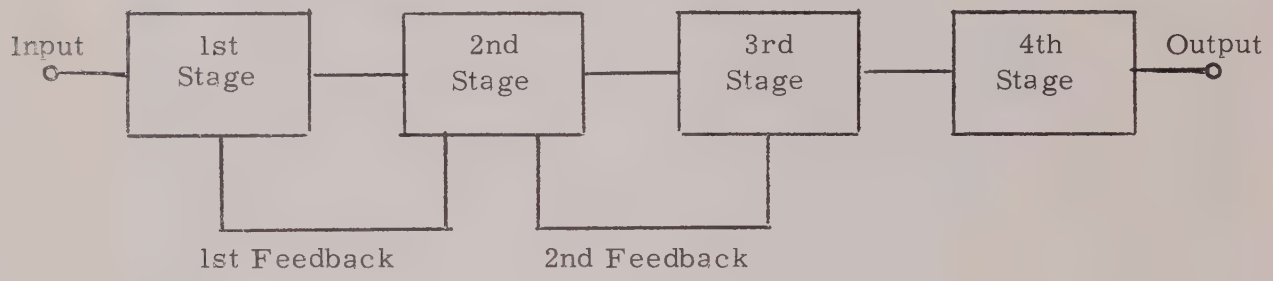


Figure 3, Functional Diagram, Model 705AF

The circuit operates as a conventional binary counter up to the count of four. On the count of four, the third stage is triggered, sending a pulse through the first feedback network, thereby triggering the second stage. Since it requires two inputs to trigger the second stage, this is the equivalent of adding two input pulses and the unit now corresponds to a binary count of six. On the count of six (which is the equivalent of eight in a binary counter) the fourth stage is triggered, sending a pulse through the second "feedback" network and triggering the third stage. This is the same result as if four additional input pulse had been applied and the unit has a binary count of twelve stored in it. The unit again operates as a binary scaler for the remaining four pulses required to reset it to zero. Therefore, by adding the equivalent of six input pulses, the scale-of-16 has been permuted into a scale-of-10.

Section 4
MAINTENANCE

When a Decimal Counting Unit is suspected of counting incorrectly, it should be interchanged with another unit in the instrument or replaced with a spare unit to determine whether the trouble is in the suspected unit or in the associated circuitry. This test should be made very carefully. The counting unit is usually the indicating device of an instrument, and is quite often accused of counting incorrectly when the fault is external to it.

Trouble-Shooting

Two methods are recommended for finding the trouble in a faulty counting unit. First, by observing the lighting sequence while driving the unit at a slow repetition rate, and second, by studying the waveform of each stage while driving the unit at a repetition rate fast enough to be conveniently viewed on an oscilloscope. It is impossible to say which method should be used in every case, since marginal failures may occur at high counting speeds and not at lower counting rates, and vice versa. The first method is the only way that a neon lamp failure can be located, and it can be used to locate component and tube failures. For this reason, it is recommended that this method be used first. Table 1 lists common troubles. Remember, tubes are the most frequent cause of failure.

Diagrams and Tables

Figure 4 shows the waveforms for each stage. By comparing these with those of a faulty unit, troubles may be isolated.

Schematic drawings will be found at the rear of the manual. The voltages shown were obtained with a vacuum tube voltmeter, a supply voltage of 300 volts, and measured between ground and the point indicated. The unit must be reset to zero to obtain the values shown.

Table 2 lists the voltages and resistances between tube socket connections and ground so that, in conjunction with the schematics and parts location diagrams, all information necessary to maintain the equipment in proper working order is available. It should be remembered that the values given are nominal, and considerable variations may be encountered owing to various line voltage conditions and component tolerances.

Table 1

COMMON TROUBLES*

SYMPTOM	CAUSE
Unit Fails to Count	(a) Insufficient supply voltage. (b) Input signal of insufficient amplitude. (c) Input signal of wrong polarity. (d) First stage inoperative.
Unit Counts Spuriously	(a) Stray output signal. (b) Pulses received through power supply. (c) External voltages picked up by output lead.
Unit Counts Erratically	(a) Input signal too large or small, incorrect rise time. (b) Supply voltage fluctuating too much.
Unit Fails to Reset	(a) Stray counts from reset switch or associated circuitry. (b) Defective component.
Unit Counts in Wrong Sequence* (the pattern of lighting is repeated after a difinite number of input pulses. One or more lights may be "On" simultaneously during a cycle provided that the number of states per cycle remains constant).	
1. Units skips every other number.	(a) First stage defective. (b) Input circuit supplies double pulses.
2. Two stable stages per cycle.	(a) Second stage defective (count can be 01 or 45). (b) Loss of drive to second stage (01).
3. Four stable states per cycle.	(a) Third stage defective (count can be 0123 or 6789). (b) Loss of drive to third stage (0123).
4. Six stable states per	(a) Output excessively loaded (count can be 012345-012345). (b) Last stage inoperative (count can be 01234501 etc. or $67^{89}_{23}89$. The count $^{8}_{2}$ indicates both "8" and "2" lamps are on. (c) Loss of drive to fourth stage (count can be 012345).

5. Eight stable states per cycle or any failure where two successive number are skipped.	(a) Second or third stage failure.
6. Ten stable states per cycle, but the lighting sequency is incorrect.	(a) Where the "0" neon lamp lights instead of the "4" the trouble is with either the "0" or "4" lamp, and in the majority of cases it is "4". This can happen on any count; zero and four were used as examples. It is also possible that more than one lamp may light in place of, or with the one that fails.
7. Twelve stable states per cycle.	(a) When lighting sequence is $0123\frac{01}{45}456789\text{-}0$, etc. (The count $\frac{0}{4}$ indicates both "0" and "4" lamps are on.) First feedback failure. Second or third stage losing emission.
	(b) When the lighting sequence is $01234567\frac{23}{89}89\text{-}0$, etc. Second feedback failure. Third or fourth stage losing emission.

*Reset Unit before troubleshooting.

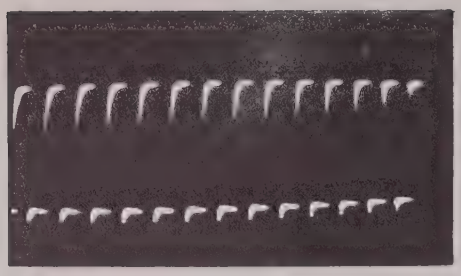
Table 2

VOLTAGES & RESISTANCES

Tube	Pin No.	D. C. Voltage to Ground	Resistance to Ground (in ohms)
V101	1	170	105K
	2	17	85K
	3, 8	37	12K
	4, 5, 9	Filaments	
	6	60	105K
	7	37	85K
V102	1	135	93K
	2	15	83K
	3, 8	30	12K
	4, 5, 9	Filaments	
	6	55	93K
	7	30	83K
V103	1	135	100K
	2	15	83K
	3, 8	30	12K
	4, 5, 9	Filaments	
	6	55	100K
	7	30	83K
V104	1	135	93K
	2	15	83K
	3, 8	30	12K
	4, 5, 9	Filaments	
	6	55	93K
	7	30	83K

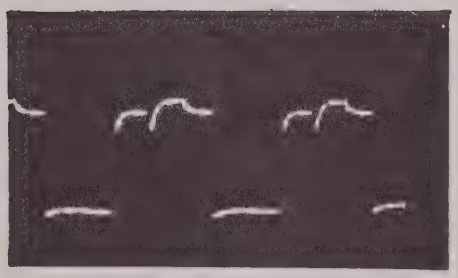
NOTE

The following waveforms were photographed from a Tektronix Model 511D oscilloscope at f4.5 and 1/2 second.

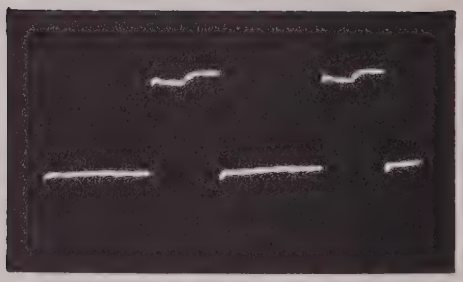


A. First Stage, Pin 6, V101, UVL + 168, LVL + 58, frequency 20Kc.

B. Second Stage, Pin 6, V102, UVL + 140, LVL + 55, frequency 20 Kc.



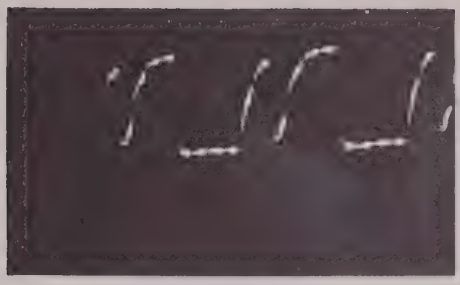
C. Third Stage, Pin 6, V103, UVL + 140, LVL + 55, frequency 20 Kc.



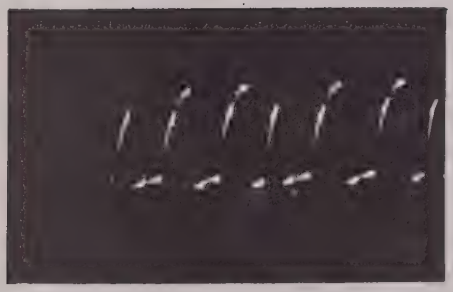
D. Fourth Stage, Pin 6, V104, UVL + 140, LVL + 55, frequency 20Kc.

Figure 4 Typical Waveforms

E. First Stage, Pin 6, V101, UVL + 168, LVL + 58, frequency 100Kc.



F. Second Stage, Pin 6, V102, UVL 140, LVL + 55, frequency 100Kc.



G. Third Stage, Pin 6, V103, UVL + 140, LVL + 55, frequency 100Kc.

H. Fourth Stage, Pin 6, V104, UVL + 140, LVL + 55, frequency 100 Kc.

Note: UVL = upper voltage level
LVL = lower voltage level
All waveforms are blanked.

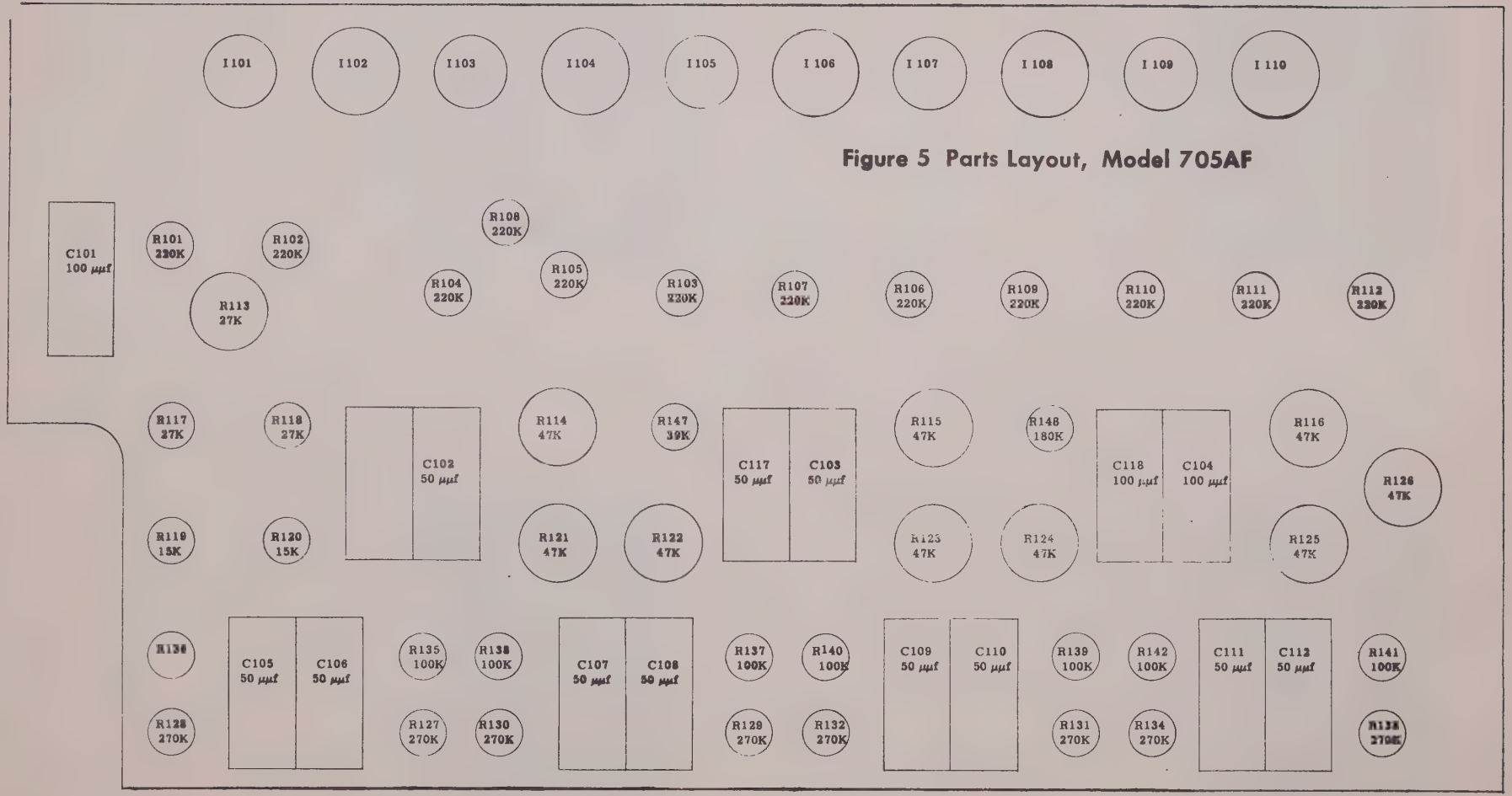
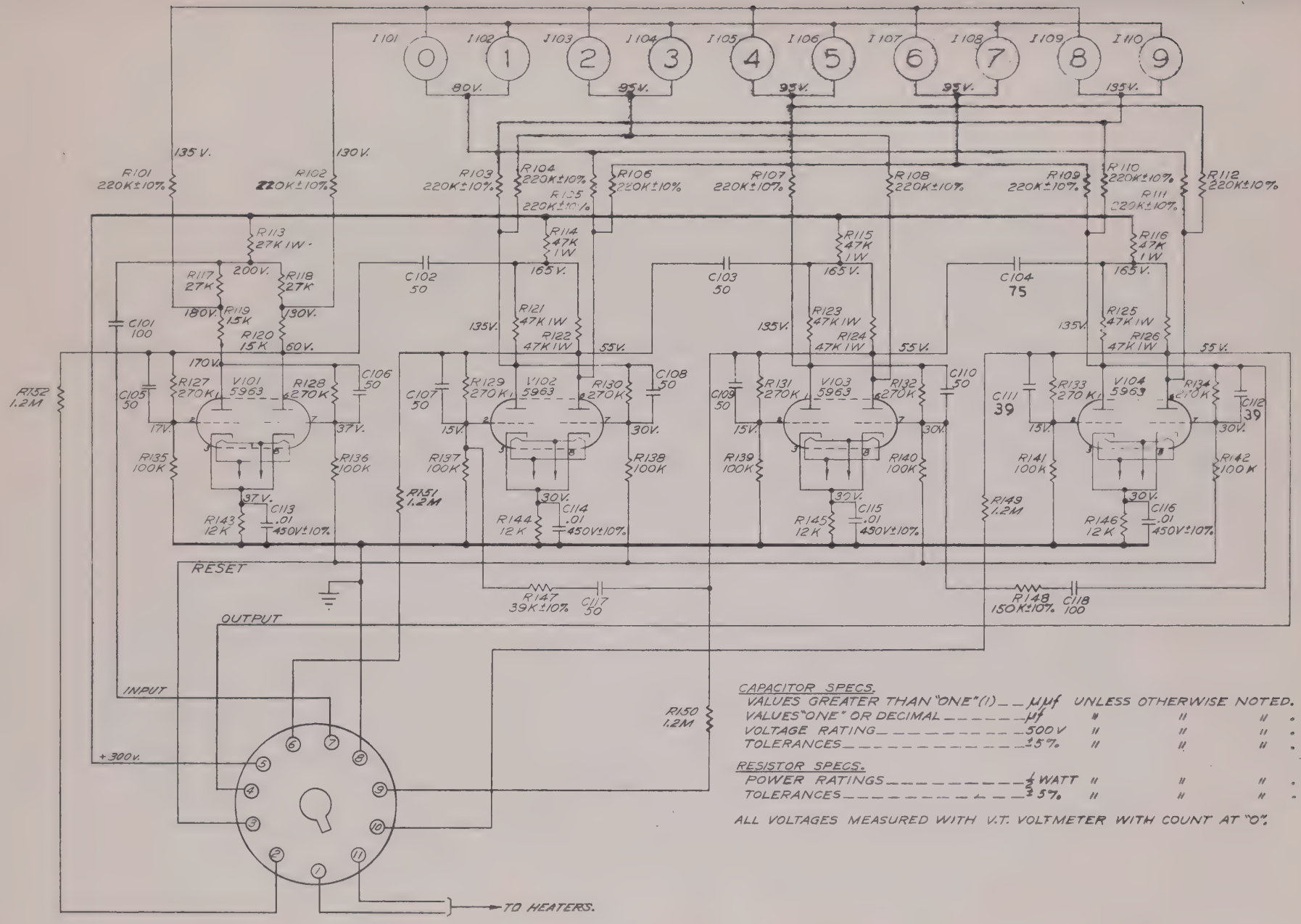


Figure 5 Parts Layout, Model 705AF

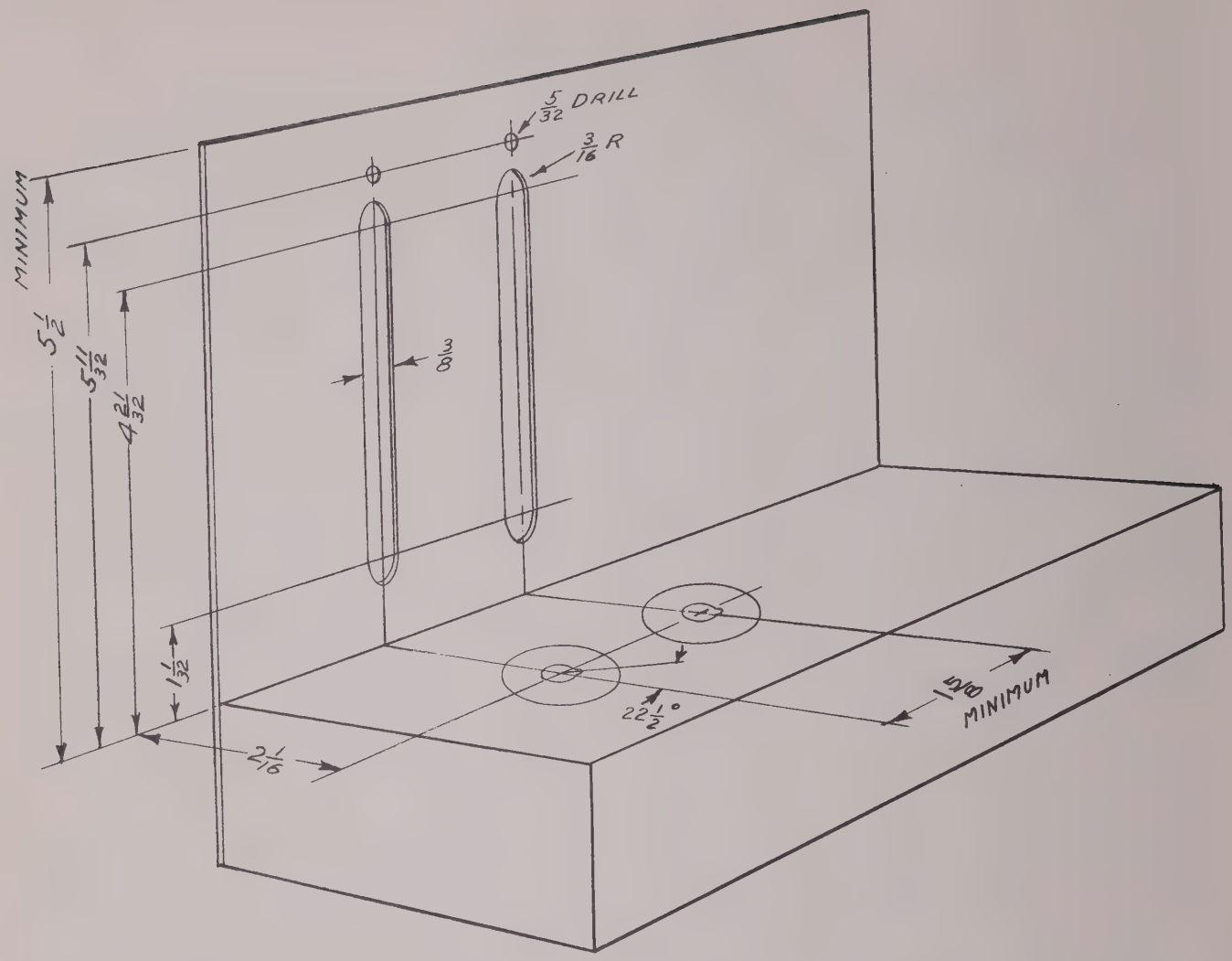


CAPACITOR SPECS.
VALUES GREATER THAN "ONE" (1) ___ μμf UNLESS OTHERWISE NOTED.
VALUES "ONE" OR DECIMAL _____ μf " " " "
VOLTAGE RATING _____ 500 V " " " "
TOLERANCES _____ ±5% " " " "

RESISTOR SPECS.
POWER RATINGS _____ ½ WATT " " " "
TOLERANCES _____ ±5% " " " "

ALL VOLTAGES MEASURED WITH V.T. VOLTMETER WITH COUNT AT "0".

Figure 6 Schematic Diagram, Model 705AF



NOTE: Dimensions are based on the use of an Amphenol "MIP" 8 or 11-pin socket and .064 metal in the chassis.

Mounting Dimensions, Model 705AF

introducing

NEW BERKELEY

INSTRUMENTS and COMPONENTS:

- FERRISTORS*
- DECIMAL COUNTING UNITS
- COUNTERS & PRESET COUNTERS
- TIME INTERVAL METERS
- EPUT* (Events-Per-Unit-Time) METERS
- UNIVERSAL EPUT* METERS
- FREQUENCY METERS
- NUCLEAR SCALERS, COUNT RATE METERS
- NUCLEAR AUTOMATIC SAMPLE COUNTERS

EASE COMPUTERS

EASE COMPUTER-QUALITY CONTROL SYSTEM COMPONENTS

Systems for:

- DATA REDUCTION
- DATA HANDLING
- DATA LOGGING
- INDUSTRIAL MEASURING & RECORDING
- INDUSTRIAL PROCESS CONTROL

*Trademark

BERKELEY
SHORT FORM CATALOG
C 703

Berkeley division of Beckman Instruments Inc.

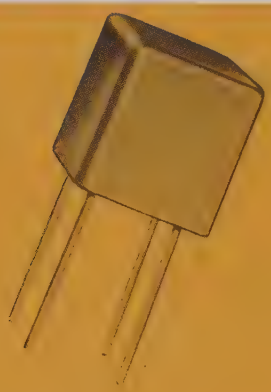
FERRISTORS* for Magnetic Amplifier and Counter Circuitry

FERRISTORS* are reliable, light weight, low-power replacements for tubes consisting of simple wire-wound coils on ferro-magnetic cores, and encapsulated in epoxy resin. They are immune to damage by shock, vibration, overload, humidity or temperature, and are ideally suited for industrial electronics where long-term reliability is an important factor.

In BERKELEY's new line of long-life counter-controllers, FERRISTORS* are used to perform all the functions of vacuum tubes in input amplifier, gate, time base, decimal counting unit, coincidence amplifier and control circuitry.

Complete technical data and prices will gladly be supplied on request.

Compact FERRISTOR* is encapsulated in 9/16" cube, with 4 pigtail leads.



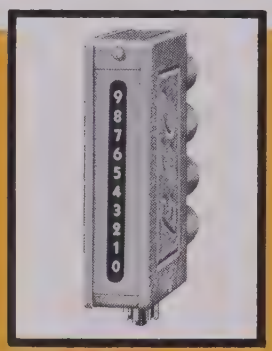
VACUUM TUBE Decimal Counting Units

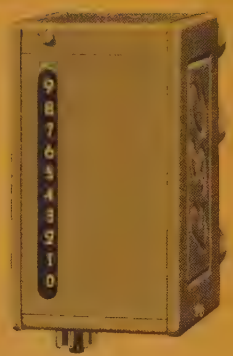
All DCU's are designed for a four-line binary coded output to drive Berkeley digital printers, remote in-line readouts, or data converters. Counts are displayed in digital form on the illuminated front panel; units may be cascaded to provide any desired total count capacity, and plug into standard sockets.

Model 705AH—100 kc max. count rate. Price, $33.00.

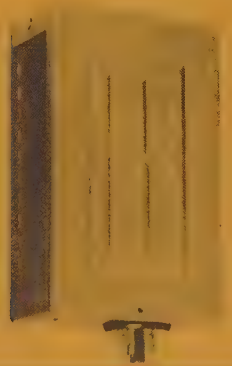
Model 707AH—1 mc max. count rate. Price, $95.00.

Model 711AH—2 mc max. count rate. Price, $110.00. Designed to drive 713AH (200 kc count rate, $75.00) which in turn drives the 705AH.





MAGNETIC Decimal Counting Units



Models 716-717 Magnetic DCU measure only 1⅞" x 5½" x 3½". Model 716 has 10,000 cps max. counting rate; Model 717, 40,000 cps. Price (either model), $110.00.

Model 736 Dual Preset Magnetic DCU produces output signal at any two presettable counts, handles up to 10,000 cps. Measures 1⅞" x 5½" x 3½". Price, $130.00.

Magnetic DCU's are capable of counting up to 40,000 pulses a second. Units may be cascaded indefinitely to achieve a counter of any capacity. Each DCU counts from 0 to 9, presenting an illuminated reading on the front panel.

Elimination of vacuum tubes permits an overall size reduction of up to 32% and a weight reduction of up to 59% over other units. Illustrated magnetic DCU's are plug-in units fitting standard octal sockets. Lower heat generation resulting from decreased power requirements permits more compact assembly than vacuum tube types.

VACUUM TUBE Preset Decimal Counting Units

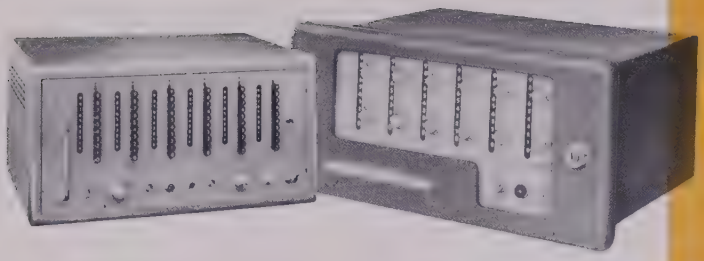
Model 730A Single Preset DCU produces output pulse at any single preset count. Price, $65.00.

Model 732A Dual Preset DCU produces output pulses at any two preset counts. Price, $75.00.

Berkeley Single and Dual Preset Counters count and display information at rates to 40,000 cps, and produce output pulses at any preset total count (Model 730A) or any two preset counts (Model 732). Output pulses will operate relays, audible or visual signals, solenoids, etc.

*Trademark

PRESET COUNTER-CONTROLLERS



Count at rates to 40,000 cps, produce output signals at any desired preset total (or any two preset counts with dual preset models). Operate on input pulse of ± 1 volt peak, or more. Instantaneous reset to zero after final count. Reliable, simple to operate. Available in 2,3,4,5 and 6-digit capacities. Long-life magnetic Model 5840 dual preset features FERRISTOR* circuitry for continuous-duty reliability.

Series 5420 single preset models range in price from $435.00 for 2-digit capacity to $740.00 for 6-digit capacity. Dual preset Series 5440 range from $560.00 (2-digit) to $840.00 (6-digit).

Series 5840 long-life magnetic dual preset counter features FERRISTORized* circuitry; 6-digit, Model 5846, $1,295.00.

TIME INTERVAL METERS

Model 7250 Berkeley Time Interval Meters provide a direct, digital reading of elapsed time between any two events, or the duration of a single event, in microsecond (Model 7260) or 10-microsecond increments.

Any occurrences that can be changed to varying voltages may be so timed. Both models may be standardized against WWV or other external standards, and have connections for driving digital printers or data converters. Provisions are also made to measure period of input signals or use as a high-speed electronic counter or frequency ratio meter.

APPLICATIONS

Timing of relays, shutters, solenoids, controls; ballistics research; measurement of viscosity; elasticity, velocity; accurate low frequency and period measurements; calibration of pulse generators, precision phase measurements, frequency ratio measurements, etc.

BRIEF SPECIFICATIONS	Model 7250	Model 7260
Range:	10 μ sec to 1 sec	1 μ sec to 1 sec
Accuracy:	± 10 μ sec, ± 1 part in 10^5	± 1 μ sec, ± 1 part in 10^6
Input Requirements:	0.1 v rms, 10 megohms, ac or dc—coupled	
Display Time:	Adjustable, 0.1 to 5 seconds (automatic reset) Manual reset also provided.	
Price: (f.o.b. factory)	$595.00	$830.00

EPUT* (Events-Per-Unit-Time) METERS

APPLICATIONS

Precision tachometry; measurement of pressure, flow, temperature, viscosity, velocity, frequency, frequency period; process control or data reduction systems; calibration of frequency generating equipment; measurement of any electrical, mechanical, optical or other physical event occurring during a precise time interval.

Berkeley EPUT* Meters automatically count and display the number of events that occur during a precise time interval. Events may be any physical occurrences that can be represented by changing voltages occurring either regularly or at random at rates to 1,000,000 per second, depending on model.

7000 Series units may be used to measure frequency or period, and also as high speed electronic counters with manual on-off control.

Model 7650 Long-Life Magnetic EPUT* Meter

Performs the same function as models described above. Employs Berkeley FERRISTORS* in all critical circuits to assure continuous-duty reliability. Ideally suited to industrial test applications such as jet and piston-engine test cells, etc. Has digital "count-down" time base for precise gating; no adjustment of time base required.

BRIEF SPECIFICATIONS

	Model 7150	Model 7160	Model 7650
Count Capacity:	5 digits	6 digits	5 digits
Count Rate:	0 cps to 100 kc	0 cps to 1 mc	0—40,000 cps
Time Bases: (decade steps)	10 μ sec to 1 sec	1 μ sec to 1 sec	0.1 to 10 sec
Price:	$775.00	$995.00	$1,495.00

*Trademark

MODELS 7250 and 7260 UNIVERSAL EPUT* METERS

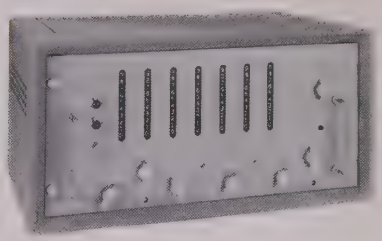
APPLICATIONS

Counting, time interval, EPUT* measurements for precision tachometry, measurement of pressure, flow, frequency, velocity, viscosity, elasticity; timing relay, shutter action, etc.

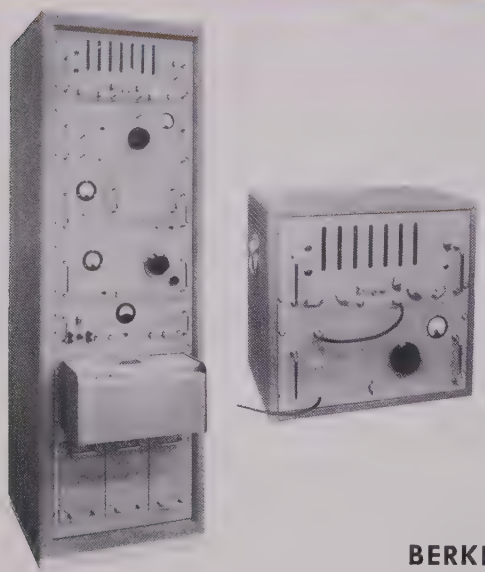
Measurement of unknown frequencies, frequency ratios, periods, etc.

BRIEF SPECIFICATIONS

	Model 7350	Model 7360
Ranges-Frequency:	0 cps to 100 kc	0 cps to 1 mc
Time Interval:	10 μ sec to 10^6 sec	1 μ sec to 10^7 sec
Period:	0 cps to 100 kc	0 cps to 1 mc
Time Bases:	10 μ sec to 10 sec	1 μ sec to 10 sec
Price:	$890.00	$1,175.00



These truly universal instruments combine high-speed electronic counting with a precision time base in multi-purpose circuitry. They function as counters, timers, time-interval meters, EPUT* meters, frequency, frequency ratio or period meters, or as secondary frequency standards.



Frequency Meters and Frequency Measurement Systems

Basic instrument is the Model 5571, capable of measuring frequencies from 0 cps to 42 mc. Addition of the Model 5580 UHF-VHF converter and suitable plug-ins extends the range to 515 mc; Model 5582B VHF converter with plug-ins extends the range to 1,000 mc. Results are displayed in direct-reading digital form. Unit will drive a Model 1452 digital printer to provide a complete frequency logging system in which results are printed on standard adding machine tape. Model 5571 is also a Universal EPUT* and Timer with same specifications as Model 7360.

Model 5571 with 5580 converter and 5580 series plug-ins for frequencies to 515 mc. Model 5571 price, $1,745.00. Model 5580 converter, $300.00; 5581 series plug-ins, $100 to $150.00 each. All are FCC-approved.

Complete frequency logging system for frequencies to 1,000 mc. Model 5571 (with 5582B converter and plug-ins), drives Model 1452 digital printer to record results automatically on adding machine tape. 5590 WWV receiver and 5585 2 to 42 mc Selective Amplifier also shown.

BERKELEY DOUBLE PULSE GENERATORS

Produce paired or single pulses. Pulse amplitude, width, polarity, repetition rate and pulse-to-pulse spacing are independently adjustable. Outputs may be mixed internally or externally. Model 903 ($440.00) can be driven externally by pulses; Model 4904 ($595.00) by pulses or sine wave generators.

BERKELEY TEST ACCESSORIES

TACHOMETER PICKUPS

Consist of magnetic pickup and toothed tachometer gear (number of teeth optional). Offered in 3 types, also explosion proof. Photocell pickups and light sources also available.

MODEL 1452 DIGITAL PRINTER

Connects directly to any Berkeley 5510, 5571 or 7000 Series instrument, prints data in digital form on standard adding machine tape. May be modified to print "Time" or "Code" information simultaneously with data. Rack mounted; available in up to 8 digits. Price (6 digit), $850.00.

MODEL 5916 IN-LINE READOUT

Large, illuminated in-line IN-PLANE figures reduce fatigue and error. Ideal for remote observation of data. Connects directly to any Berkeley 5510, 5571 or 7000 Series instrument. Price (6 digit) $775.00.

*Trademark

FIELDS OF ACTIVE PARTICIPATION

1. High speed, high accuracy analog-to-digital and digital-to-analog conversion
2. Digital timing and recording systems
3. Automatic logging systems (static or dynamic)
4. High speed telemetered data handling
5. Industrial tachometry-fuel flow measuring and recording systems
6. Complete closed loop analog control systems
7. Industrial batching-sorting control systems
8. Automatic nuclear sampling and recording systems
9. Special-purpose digital computers
10. General-purpose data handling and data reduction systems
11. Machine tool control

Telemetered Data Handling Systems

Among recent systems developed by Berkeley is one capable of high speed measurement and recording of FM and FM-commutated data. Analog data represented by a frequency-modulated signal is continuously decommutated, measured, operated on, and the corrected data presented at the output in both digital and analog form. Features include:

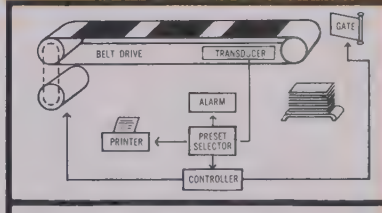
1. Compensation for tape wow and flutter
2. Compensation for transducer drifts
3. Accuracy to ± 0.1%
4. High speed digital computation

Other systems can be provided for pulse code telemetering, featuring an airborne electronic commutator, a reliable airborne magnetic analog-to-digital converter, and on-line computation of data on the ground.

Standard component blocks have also been developed for use in telemetering systems handling Pulse-Width and Pulse-Amplitude modulated signals.

Typical Systems

1. Steel mill counter-controller. Counts, stocks, batches and records steel sheets. Eliminates costly give-away.
2. Jet engine tachometer controller. Measures high rotational speeds to an accuracy of 0.001%.
3. Tape-data-to-punch-card system. Reduces multiple channels of magnetic tape data to punch cards; does in 30 minutes a task that formerly required 80 hours.



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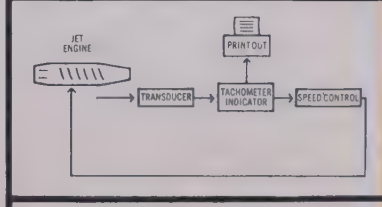

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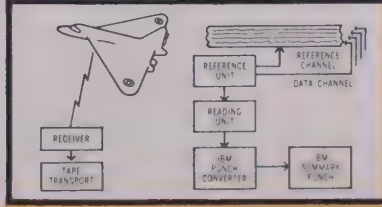


3

Model 5692 Digital Flow Indicator

Automatic Logging Systems

Berkeley division has long been actively engaged in the investigation and manufacture of complete data handling systems. The approach used is to accumulate standard blocks which can be assembled into a complete system to meet individual customer requirements.

Both dynamic and static logging systems can be provided for the sampling and recording of temperature, pressure, RPM, fuel flow, position and other analog quantities.

Speed of sampling may range from 1 sample per second to 40,000 samples per second with accuracies to ± 0.1%. Inputs can be from thermocouples, strain gages, or digital transducers.

Typical systems include either mechanical or electronic commutator, analog to digital converter, programmer, output storage unit and recording device.

Timing and Recording Systems

With the use of modified digital time interval meters and digital recorders, as manufactured by Berkeley division, complete industrial timing and recording systems can be manufactured to meet individual requirements.

Timing accuracies to ± .1 microsecond can be provided with recordings on standard adding machine tape, paper punched tape, magnetic tape, IBM cards, typewriter, teletype machine, by the use of Berkeley data reduction converters which operate with all Berkeley instruments.

Model 5692 Digital Flow Indicator provides four-digit presentation, reading directly in pounds or gallons per hour either as a flow indicator or totalizing meter. Works with any digital flow meter.

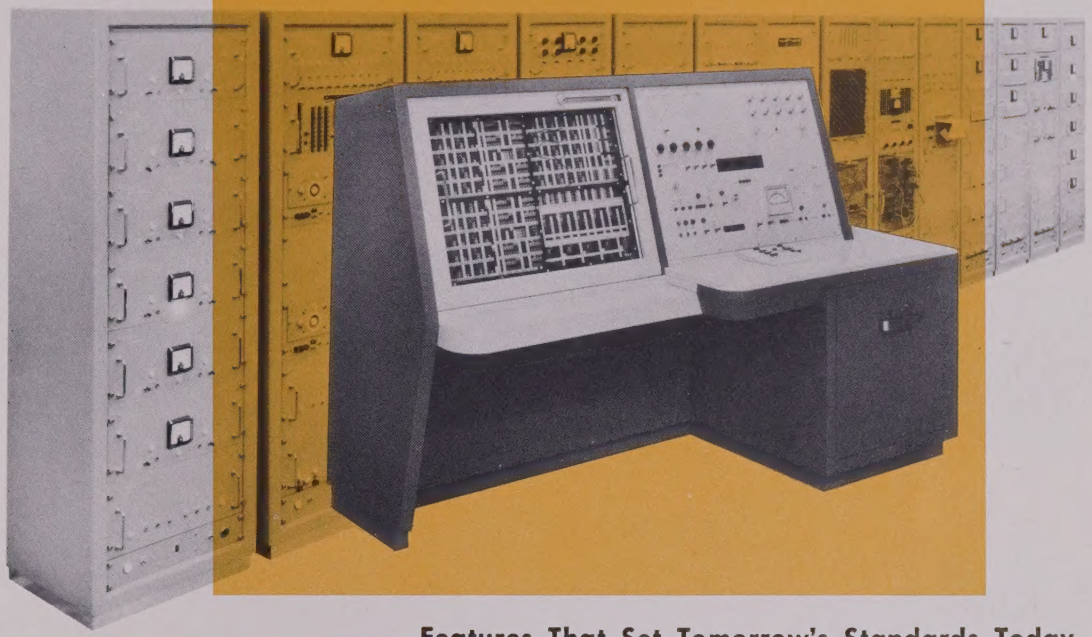
Automatic Nuclear Sample Counter automatically counts and records data on printed tape; handles up to 250 samples. Berkeley's complete line of Nuclear instruments includes decimal scalers, count rate meters, scintillation counting systems.

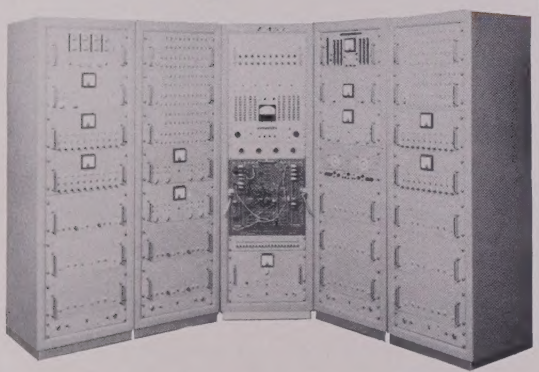
New *EASE** 1200 Series Analog Computers

The EASE* 1200 series represents maximum convenience and accuracy in large scale analog computers, including completely automatic and/or remote control of all attenuator settings by a serial type keyboard and/or punched tape input. In the EASE* 1200, the user finds tomorrow's computer today.

The patch bay system is all new, featuring complete shielding and insulation to eliminate accidental shorting of patch cords. The patch bay has sufficient capacity (3600 terminals) to interconnect more than:

- **100 dc amplifiers**
- **16 servos**
- **350 keyboard-controlled attenuators**
- **30 electronic multipliers**
- **250 spare terminals**
- **Adequate trunk lines and terminals for limiters, biases, etc.**





MEDIUM-PRICED — .05% accuracy; includes pushbutton control unit to handle up to 100 servo-set pots, 50 amplifiers, 16 electronic multipliers. Various combinations of function generators, servo multipliers and special equipment available.

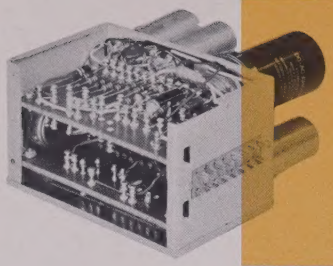
Features That Set Tomorrow's Standards Today

1. **High accuracy and stability**
2. **Complete keyboard control of all problem parameters including initial conditions and coefficients**
3. **Automatic punched tape or card attenuator setting**
4. **Complete and automatic recording of all problem parameters**
5. **Built-in problem checking system**
6. **Built-in 6-channel chart recorder**
7. **Completely shielded patch cord and patch board system**
8. **"Human engineered" centralized console design**
9. **Instantaneous and "stored" overload indication**
10. **Unitized design for complete flexibility and future expansion**
11. **Modular construction**

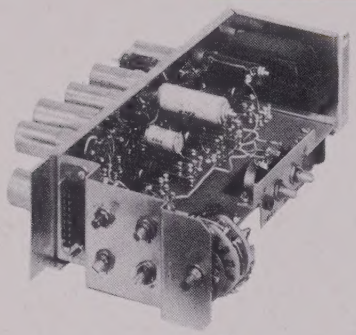
LOW-PRICED — 1% accuracy; as shown includes 10 amplifiers (stabilized or unstabilized), 16 coefficient pots, 10 initial condition voltages for integrators. Model 1031 patch board accommodates up to 42 decade stepping resistors and multiturn pots, 30 amplifiers, for future expansion.

*Trademark

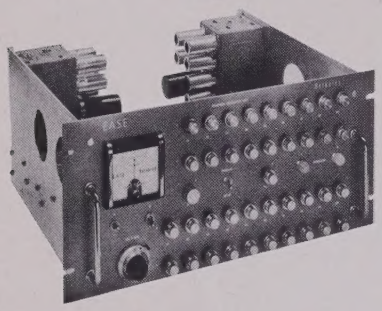
*EASE** Computer-Quality Components for Control Systems



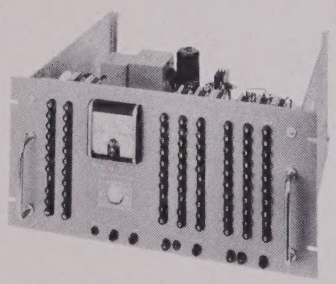
Model 1048 DC Amplifier... a chopper-stabilized operational amplifier with open loop gain in excess of 10^8 and extremely low drift. Adaptable to many computing functions where accuracy and stability are important such as amplification, inversion, addition or integration. These amplifiers have also been used as isolation devices, as highly stable recorder drives, as difference amplifiers, etc.



Model 1056B Electronic Multiplier... a highly stable device with less than 0.2% drift in any 8-hour period, static accuracy of 0.2% of full scale, and frequency response flat within ½ db to 500 cps. Useful wherever accurate, fast multiplication of dc voltages is desired at reasonable cost.



Model 1073 Function Generator... a self-contained diode function generator requiring no patching or external connections. Approximates non-linear function by 20 straight-line segments, using locking-type knobs for adjustments, accurate null-reading meters, and precision potentiometer. Can be used for linearizing outputs of transducers or non-linear metering devices, to compensate for non-linear values or transfer characteristics in process control, or for simulating characteristic behaviour of physical systems.



Automatic Setup Function Generator... completely self contained diode function generator; one control unit sets up to 10 function generators automatically. Can be used in combination with a Berkeley servo as a "mapreader" to generate functions of two variables.

Complete technical data price and delivery information on any Berkeley product will gladly be supplied on request. Call your nearest Berkeley representative (listed below), or write us now.

*Trademark

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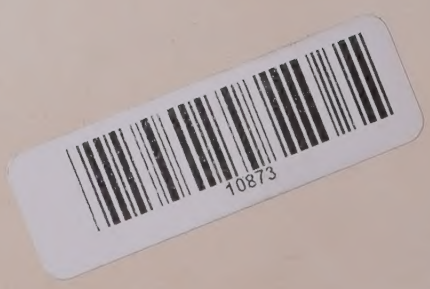
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